ELECTRICAL REVIEW

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VIEWS, NEWS AND INTERVIEWS.

Professor John P. Barrett, electrician of the World's Fair, suggests that the buildings and grounds of the Fair can be illuminated by electric light for a much lower figure than the Board of Directors first estimated. Professor Barrett thinks that the electrical companies having big displays can be given the contracts for lighting, and by making slight additions to their exhibition plants they can furnish the required light at a comparatively low price.

In view of the fact that experience in the electrical field counts for so much, the following anecdote of Goethe is *apropos*: A young man once asked the great German poet and philosopher, "What is experience?" Goethe replied, "Experience, my young friend, is that experience which a man experiences in experiencing his experiences." The young man turned away with the remark, "You are a fool." It is pleasing to note that years afterward he came to Goethe, apologized, and acknowledged that his question had received the only possible reply.

An electric car was put to a novel service last week by two wide-awake conductors. Two Italians had stabbed a man near Gravesend, L. I., and then ran up the Coney Island electric street railway. The two conductors hearing of the assault and knowing that the men had run up the road, jumped on a car and ran it at full speed after the fugitives. After a lively chase the Italians were caught and jailed.

There is a man in New York who is known as a cable packer. His business is to do to cablegrams what an editor is often required to do to contributions; that is, boil them down. The cable packer will take a cablegram of 50 or 100 words and express the same ideas in perhaps 10. Of course, this is done by means of a cipher code, which is unraveled by a correspondent at the other end of the line. The cable packer makes his money in commissions received. This man established his business 35 years ago, and made quite a little at it for some time, but he says that trade is falling off now. The reason for this is that former patrons have invented codes of their own and now do their own cable packing.

A prominent official of the Edison General Electric Company told the following story as illustrating how little the outside world knows of electrical matters: "Some years ago one of New York's biggest millionaires sent word for the gentleman in question and Mr. Edison to visit him and talk over the matter of lighting his house with electricity. The call was made, and in the course of the conversation the millionaire wanted to know if Mr. Edison couldn't put in some kind of an electric motor which would run the steam engine that operated his passenger elevator.

The students of Glasgow University recently presented an address to Sir William Thomson congratulating him on his accession to the presidential chair of the Royal Society of London. Sir William, in thanking them for this mark of sympathy, avowed his sympathy with their efforts and objects, and declared himself a student like themselves. "I have been a student of the University of Glasgow for 55 years," said he, with characteristic modesty, "and I hope to continue a student of this university as long as I live." The Winter session having ended at Glasgow, Sir William has gone to London to fulfill his duties as president of the Royal Society.

Paris is laughing over a joke about an American inventor who is said to have patented an electric corset that is to bring about the reign of morality at once. If one of these articles is pressed by a lover's arm it at once emits a shriek like the whistle of a railway engine; and the inventor claims that he has already married three of his daughters, owing to the publicity thus thrust upon a backward lover.

The Copenhagen Thermostat.

The device illustrated in the accompanying cut is manufactured by the Copenhagen Electric Alarm Company, 92 Sycamore street, Cincinnati, Ohio. Mr. C. D. Muller is secretary and general manager of the Company.

The device consists of a base made of insulating material, binding-posts, and a copper capsule, about the size of a dime, filled with a liquid. The capsule is backed by a corrugated silver diaphragm. The liquid under the action of heat becomes partly vaporous and instantly forces the silver diaphragm from its normal concave position, to a convex position, closing the circuit, on which is placed an electric alarm bell. The Copenhagen alarm may be arranged to operate at any desired degree of heat by varying the formula of the liquid.

The device is designed for use in private houses, manufacturing plants, or in fact any place where there is a possibility of fire. The contact points are so placed that it is

THE COPENHAGEN THERMOSTAT.

impossible for any foreign substance to interfere with the operation of the thermostat.

The Copenhagen alarm can also be arranged for greenhouses or similar uses where it is desired to note a fall in temperature. The engraving is the exact size of the device.

Magnetic Glances.

POSITIVE.

Your eyes, sweet Nan, so softly blue, glance upward to my own—
That instant ev'ry tingling vein knows that its drop has flown
To swell the flood, tumultuous, that in my beating heart,
Wildly insensate—strives to burst its ligaments apart.

NEGATIVE.

If then your eyes down-drooping in a gentle transience go—
That instant ev'ry drop of blood sinks from my heart and slow
Trickles along its veined path until its absence fold
My heart in aching helplessness and misery of cold.

—EDWARD LEODORE SMITH.

A Kookaburrah.

Mr. Lucien Henry, of Australia, has written a book on "Australian Decorative Art." One of his antipodean designs for an electric lamp is illustrated in the accompanying engraving, for which we are indebted to the *Illustrated Sidney News*. In this design Mr. Henry has used the well known (?) Kookaburrah, or laughing jackass, as a model, and has produced a very quaint and artistic electric lamp. It was by using, for purposes of design, the objects by which they were surrounded that the Egyptians, Greeks and Etruscans grew so excellent in their skill in executing and designing in bronze, terra-cotta, enamel, pottery, and in textile fabrics, and there is little doubt that

A KOOKABURRAH.

Australian designers have ready to their eye and hand forms as pure and adaptable as had the older nations. The *News* says that this work of Mr. Henry's will be but the *avant courier* of many others, if the public have the taste to perceive and the spirit to adopt what is placed before them.

The electric railway at Jamestown, N. Y., has recently been completed. The line is about 12 miles in length, and connects with Lakewood, the well-known summer resort on Lake Chautauqua, four miles west of Jamestown. The power-house is equipped with three 250 horse-power Dick & Church automatic cut-off engines, and three Short railway generators. A large marbleized slate switchboard carries every instrument necessary to safety and convenience. There are three Sterling boilers equipped with Roney mechanical stokers. The car equipment consists of 10 Short motor cars, and as many trailers of the open type. The cars are handsomely finished in black, picked out in silver and gold.

The Tools of Modern Warfare.

INTERESTING LECTURE AT THE ELECTRIC CLUB BY HIRAM S. MAXIM.

The novel idea of firing in a parlor several hundred shots, at the rate of ten a second, from a Maxim automatic gun, was accomplished at the Electric Club, Thursday evening, May 28. Mr. Hiram S. Maxim, the eminent inventor, performed this feat in the course of his lecture on "The Tools of Modern Warfare." Besides being the inventor of what is probably the most rapid firing gun in existence to-day, Mr. Maxim is an electrical inventor of considerable repute, as is doubtless well known. His lecture before the Club did not deal with electrical matters, but was none the less interesting and instructive. Mr. Maxim began his address with a short talk upon gunpowder of various kinds, showing the development from the ordinary black powder to the most modern smokeless powder. This part of the lecture was illustrated with practical experiments in powder-firing, showing that the smokeless powder was smokeless, and was considerably slower in firing than the common powder; that is, when fired in the open air it made no report. Then taking up an old flint-lock musket, such as was used in the Mexican war, Mr. Maxim traced the development of the small arm up to the repeating rifles of to-day. Coming to automatic firing guns, Mr. Maxim referred to Dr. R. J. Gatling, of Hartford, as the first man who ever made a machine gun. The lecturer stated that Dr. Gatling was one of those men who were ahead of his time, as he invented a rapid firing gun before the day of metallic cartridges. The next development in the line of machine guns was the French mitrailleuse, which consisted of 20 or 30 barrels fastened in one, and all fired at the same time. The next step in machine gun development was the invention of the Nordenfeldt gun, which was practically a Gatling gun spread out flat. The Gardiner gun, operated by a crank, was the next progressive step. The chief fault of this gun is that when firing too fast the gun becomes jammed and refuses to work. Colonel Barnaby and his brave soldiers who faced the Arabs were cut down owing to this fault of the Gardiner gun.

"This, gentlemen," said Mr. Maxim, affectionately placing his hand upon a little gun on wheels, which stood beside him in the parlor, "is the latest and most modern development of automatic machine guns. When I was a boy my father spent a great deal of time trying to invent guns. We lived in a wood country, so the most of our guns were made of wood. He kept me at work designing and making drawings for wooden guns from the time I was 14 years old. Many years ago I was in the South and fired a musket for the first time. The recoil kicked me over, and when I got up I had a new idea. It occurred to me that the recoil could be made to do the work of firing the gun. With that idea in mind I began my experiments, and this gun is the result. The principle is simplicity itself. The cartridges are placed on a long strip of canvas, which feeds through the gun at right angles to it. The firing mechanism is

all contained within a very small compass. A button placed on the breech of the gun is used as a trigger. The first shot is fired by pressing this button, which releases one of two hammers and fires the first shot. After that the recoil of each shot sets the hammer, feeds the cartridges, fires the gun, ejects the shells, and so on, through the whole process, till the end of the strip of cartridges is reached."

The lecturer had placed across the front of the parlor a large iron pipe, with which was connected a smaller pipe running up into the chimney below the mantelpiece. The Maxim gun was wheeled around and pointed into the large iron pipe, which contained wads of canvas at the opposite end. A canvas strip, carrying 333 cartridges, was placed in the gun, and sitting down on the little rest placed at the back of the gun, Mr. Maxim dilated for a few minutes upon what was to be expected, and then pressed the button. The gun did the rest. There was a sharp "ping," a little puff of smoke from the chimney, and one shot had been fired. Then 49 shots were fired before anybody had time to take out a watch. Then someone asked Mr. Maxim to count off 20 cartridges on the belt and fire them. This was done, and it was discovered that the 20 shots were fired in just about two seconds.

By this time quite a crowd had collected in front of the Club house, and enjoyed the bombardment of the mantelpiece from without.

"The quickest work we ever did," continued Mr. Maxim, "was to fire 2,600 shots in three minutes. If I aim the gun at its highest elevation I can fire 600 rounds into the air before the first bullet reaches the ground." After relating some interesting reminiscences of his experiences with the gun, including the fact that Sir Francis de Winton was the first man to put the Maxim gun to practical use in warfare, Mr. Maxim stated that he was prepared to answer any questions which might be asked.

Dr. Gatling said: "As I was the first man to make a machine gun, I will crave your indulgence for a few minutes. I used to live in Indianapolis during the war, and frequently saw regiments leaving for the front. Many of them came back in boxes, and I found that most of them died of sickness or privation, and few of bullets; so I decided that if I could invent a gun with which one man could do the work of a hundred, there were 99 men who could stay at home. So I invented the Gatling gun. I argued that the surest way for the nations of the earth to keep peace was to make war so terrible that all of them would be afraid to try it. I think Mr. Maxim and myself can lay claim to being peace-makers."

Messrs. J. D. Bishop, F. R. Colvin, W. J. Hammer and Felix Gottschalk also participated in the discussion which ensued. General Barney moved a vote of thanks to Mr. Maxim for his entertaining address, which was unanimously seconded and carried with applause.

The Club house was in gala dress, and was comfortably filled by the members and their invited friends. Among those present were the following: Dr. R. J. Gatling, Isaac Maxim, President Samuel Insull, Richard Dyer, W. J. Jenks, Felix Gottschalk, Dr. Otto A. Moses, Stephen D. Field, W. J. Hammer, Dr. J. B. de Lery, Geo. M. Phelps, T. C. Martin, Harold Binney, Henry J. Conant, G. B. Muldaur, C. A. Gerlach, Gen. C. H. Barney, F. R. Colvin, P. H. Alexander, Henry B. Cram and R. B. Corey.

The Westinghouse Multipolar Generators.

The Westinghouse Electric & Manufacturing Company has just placed upon the market a compound-wound, multipolar generator, built in three sizes, viz, 125, 250 and 500 horse-power. By referring to the accompanying engravings it will be noticed that in general design these generators resemble the well-known Westinghouse alternating current dynamo. There is the same cylindrical yoke parting along a horizontal plane through the shaft, and the same arrangement of inwardly pointing pole pieces, but with a much smaller number of the latter.

The 125 and 250 horse-power machines have, as shown in Fig. 1, four pole pieces, and in the 500 horse-power size, Fig. 2, there are six poles. In this latter machine, the shaft has a bearing outside of the pulley, which relieves it in a large degree from the bending strain and adds much to the rigidity of the armature. The pole pieces are built up of thin sheet-iron plates bolted together and cast into the cylindrical yoke. The shunt and series coils are wound side by side upon metal bobbins which are then slipped over the pole pieces and held in place by bolts. The insulation of these coils, as well as that of the armature, is of ample thickness and of superior quality.

The bearings are self-oiling as well as self-aligning and a great amount of bearing surface is obtained, owing to the length and large diameter of the journals.

The armature is of the gramme ring type, the core being laminated in the usual manner. The armature and series coils are wound with wire of great capacity, and as a consequence the heating effect is almost unnoticeable. In fact, when it is stated that the electrical efficiency of these generators is from 94 per cent. to 96 per cent. at full load, the perfection of the design will be admitted at once.

These machines are wound for 500 volts but they can be worked up to 550 or even 600 volts with the same armature speed, by throwing resistance out of the shunt circuit with the hand regulator.

In no respect is the excellent design of these generators more apparent than in the matter of regulation. The action of the series coils is such as to cause a considerable rise in voltage as the current being drawn from the machine increases. It is claimed that even at full load this rise in voltage is sufficient to make up for any ordinary loss or "drop" in the line.

The number of sets of brushes correspond to the number of pole pieces, and the alternate ones, being of the same polarity, are connected together. Each individual brush has its own spring, by means of which its pressure on the commutator may be adjusted and any one may be removed without disturbing the others. The dynamos are reversible and may be run in either direction. We give a view of a railway switchboard equipped with Westinghouse appliances, some of which, namely, the circuit breaker and lightning arrester, have previously been described in detail in these columns. This board accommodates three generators and three feeders.

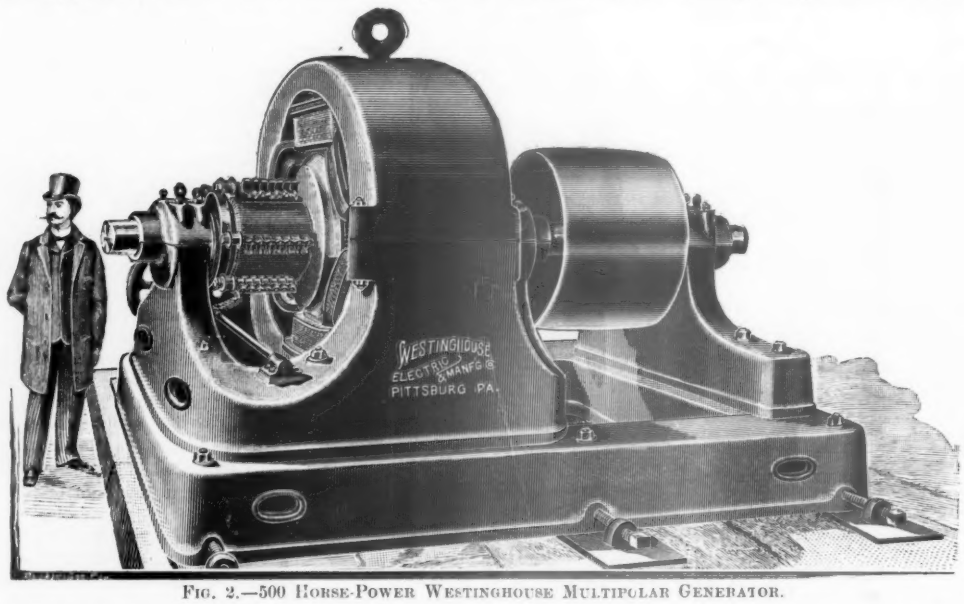

FIG. 2.—500 HORSE-POWER WESTINGHOUSE MULTIPOLAR GENERATOR.

Professor Hertz and His Work at Bonn-on-the-Rhine.

[Correspondence of the New York *Tribune*.]

This writing is of an epoch in the history of electricity. It is not remarkable that America should lead the world in taking practical advantage of so useful a servant, but one is surprised to note how much she is in the lead. Many a town of less than 10,000 inhabitants in the United States contains more electrical appliances than some of the larger cities of England and Germany. In Liverpool, Cologne and such cities, even the electric light is found only at large railway stations, and electric street cars are unthought of.

And yet in both German and English laboratories electricity is studied, as it always has been, with great interest and greater results.

The epoch to which I have referred is the discovery of electrical waves which behave very much as light and heat waves do; and can be put through all the paces of reflection, refraction, interference, echo and the like, by methods well understood by everybody at all familiar with sound waves. That electrical energy may be transferred by ether waves has been believed by some for years, but its practical demonstration had been almost despaired of when Prof. Henry Hertz, professor of physics in the University of Bonn, hit upon a splendid series of experiments which give a decisive answer.

Professor Hertz is a solid matter-of-fact, unassuming, brainy man, remarkably young to have done what will, in scientific history, put him in line with Faraday and Maxwell. He was born in Hamburg, in 1857, and received his earlier education in one of the private schools which since then have been starved out by the inauguration of the present system of public education throughout the German Empire. While in the gymnasium he did not form the usual habit of excessive beer drinking, which occupies the most of the thought and vitality of from 80 to 90 per cent. of the German university students; the foreign students of the German universities, having an object in view in coming so far, if included in this estimate, would increase the per cent. of faithful students very materially.

At 18, Professor Hertz decided to be a civil engineer, and devoted himself for a year and a half to special study in that direction; but finding that it would require years for him to become self-supporting, and that the work was full of monotonous details, like estimating quantities of brick and counting and passing upon the qualities of stone, he abandoned the idea, and, after his two years of military service, was attracted to Berlin by Professor Helmholtz. In 1881 he became assistant to that greatest of all German physicists. Two years later he accepted a position in the University of Kiel, which he exchanged in 1885 for the chair of physics in the Polytechnic School of Carlsruhe, the oldest of the kind in Germany. Soon after the death of the well known mathematical physicist, Professor Claussius, in 1889, Professor Hertz was appointed professor of physics in the University of Bonn. He is a splendid example of the three necessary elements to success—innate ability, hard work, fortuitous circumstances. His present situation is unusually favorable for work. His chair requires four lectures of 45 minutes each per week. The remainder of the time is his own, except that he has chosen to devote a considerable part of it to the building of a practical working laboratory.

The physical department is one wing of the front of the former palace. It comprises in its two stories 16 rooms, from any of which the outlook is charming.

Professor Hertz's lecture-room is the former dining-hall. Its 16 Corinthian columns and deeply frescoed ceiling are in striking contrast with the chalk-boards and rather clumsy elevated seats of a typical German lecture-room,

All of the rooms have massive foundations and walls from three to four feet in thickness. Besides a fine lecture outfit, Professor Hertz is gathering the instruments of precision necessary for a high grade physical laboratory, which has been in operation only since his coming.

The beautiful experiments that have made his name so familiar all over the scientific world are based upon an ingeniously devised metal ring, or double plate, which picks up electrical waves much as one tuning-fork responds to another of the same pitch.

The experiments do not pretend to tell what causes the electrical waves, any more than experiments with light or heat waves explain what is going on in the sun to produce them. There is an ultimate "How?" in all such inquiries which never has, perhaps never will be, fully answered. But they do tell a vast deal, and they point strongly to practical results. You may not know in its utmost profundity the nature of a mule, but he is a good deal easier to halter when you find out just how far his hind feet can reach.

The experiments of Professor Hertz, aside from the conclusive demonstration which they furnish of Professor Maxwell's mathematical theory that time is required for the transmission of electrical energy, and that energy cannot act in time through a vacuum, are capable of very great practical application.

The present methods of generating electricity are not only exceedingly wasteful of energy, but they seem to have come to a stand. The dynamo and the carbon seem to be doing their level best, and yet that is not nearly enough to please the economical turn of modern science. What next? Something must be substituted for the carbons; or some way of getting at the electric energy less wasteful than steam must be found. Last evening I witnessed some trials by a life-long German experimenter with zirconia. The performance was splendid, but the expense is even greater than before.

Professor Hertz's results, coming at just this crisis, are most opportune. By them we know that electrical energy can be transmitted in waves whose period of vibration is somewhat slower than that of heat waves. These waves can be caught by his apparatus and reproduced as the still more rapid waves called light.

The problem of the present is to arrange: First, a method for producing these electrical ether waves more nearly constant than the rapidly disappearing ones of Professor Hertz's "primary;" and, second, an instrument to intensify the effects produced by the Hertz "secondary."

There are those who will say "Pshaw, it can't be done;" but it is only a question of degree, not of kind. When Edison put his first platinum filament into the Patent Office there were those who said "Pshaw;" but the modern incandescent lamp is only an improvement in degree, not in kind. When Professor Bell first tried his telephone, it was faint and unsatisfactory, and most scientific people said "Pshaw;" but talking from New York to Chicago is an improvement in degree, but not in kind. So the difference is one of degree and not of kind, when we look forward to a time when an audience room or a street may be filled with artificially produced ether waves, just as now we fill them with the sound waves from an organ or a band; and when these ether waves can be picked up by conveniently situated receivers and reproduced as light or heat or motive power, just as now one ear or any number of ears within range of the sound waves may pick them up and hand them over as music. Professor Hertz's "secondary" weak illumination is precisely the same in principle. The problem is neither unthinkable nor unscientific. No prudent person will declare that it cannot be solved.

The Incandescent Lamp Suit.

The suit of the Edison Electric Light Company against the United States Electric Lighting Company, involving the right to manufacture incandescent electric lamps, was begun May 26, before Judge Wallace, of the United States Circuit Court of New York city. Clarence A. Seward, Grosvenor P. Lowrey and Richard N. Dyer, appeared as counsel for the Edison Company, and Eaton & Lewis as its attorneys. Counsel for the United States Company were Edmund Wetmore, General Duncan and Frederick H. Betts, and Kerr & Curtis, attorneys.

This suit, it will be remembered, has been pending for several years, in the course of which much testimony has been taken, filling many volumes. In all there are seven printed volumes containing over 50,000 words.

The suit is brought to enjoin the defendants from the manufacture and sale of incandescent electric lamps, and is based on a patent issued to Thomas A. Edison, January 27, 1880. The plaintiff claims that this patent reserves to him the right to manufacture and sell the incandescent electric lamp, in which a thread-like filament of specially prepared carbon, with platinum conductors, is used. The claim also includes the glass globe of the lamp. There are at least 50,000 incandescent lamps manufactured every day, and should the plaintiff win the suit, the royalties which will accrue to the Edison Company are estimated at $2,000,000 a year for the unexpired term of the original patent. This case is the most important in the history of the electrical industry since the decision of the great telephone dispute.

The plaintiff also seeks to recover damages for the manufacture and sale, by the defendant, of the lamp in question since about 1883. The defendants contend that the patent in question reserves to Edison the exclusive right to manufacture and sell only the particular form of lamp and filament therein described, and not to other forms in which the filament is used. A question involving certain foreign patent rights is also at stake.

Mr. Dyer opened the argument for the plaintiff. He explained in detail, and by the aid of models, the manufacture of the lamp in dispute, and quoted the decision of Justice Butts in the case of the Edison-Swan Company, against the patents of the English lamp, which was patented in 1879. This case was tried in England, and was decided in favor of Mr. Edison. Mr. Dyer's argument was exceedingly technical, very detailed, and of considerable length. General Duncan opened the argument for the defendants and is to be followed by Mr. Wetmore. Mr. Lowrey will complete the argument for the Edison Company.

The present case is really a question between the Edison Company and the field. If the plaintiff should win, it would practically throw the entire manufacture of incandescent lamps into the hands of the Edison Company, for the unexpired term of the patent, as it is probable that no other manufacturer would be able to compete with them and pay the required royalties. The final decision of the case will be awaited with great interest by the electrical fraternity.

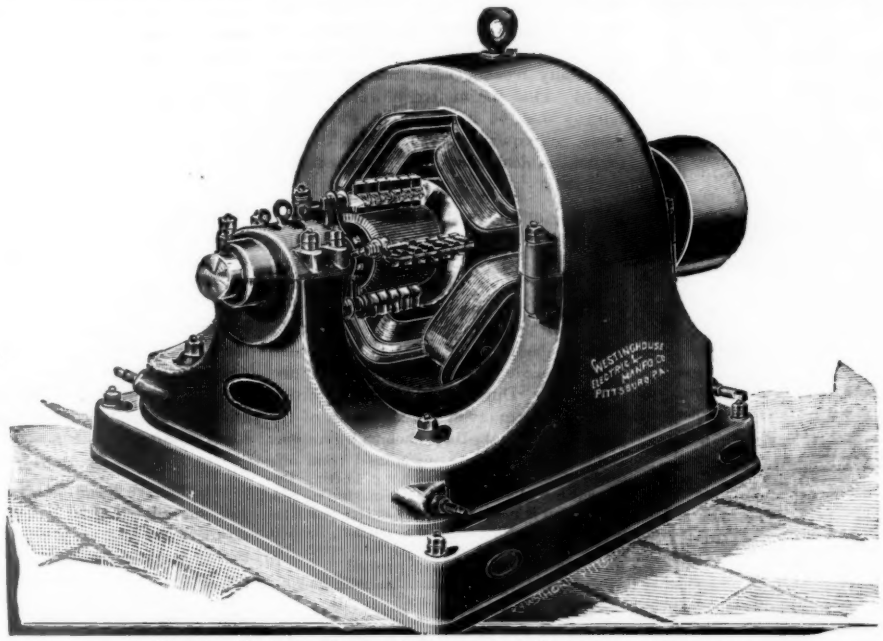

FIG. 1.—125 HORSE-POWER WESTINGHOUSE MULTIPOLAR GENERATOR.

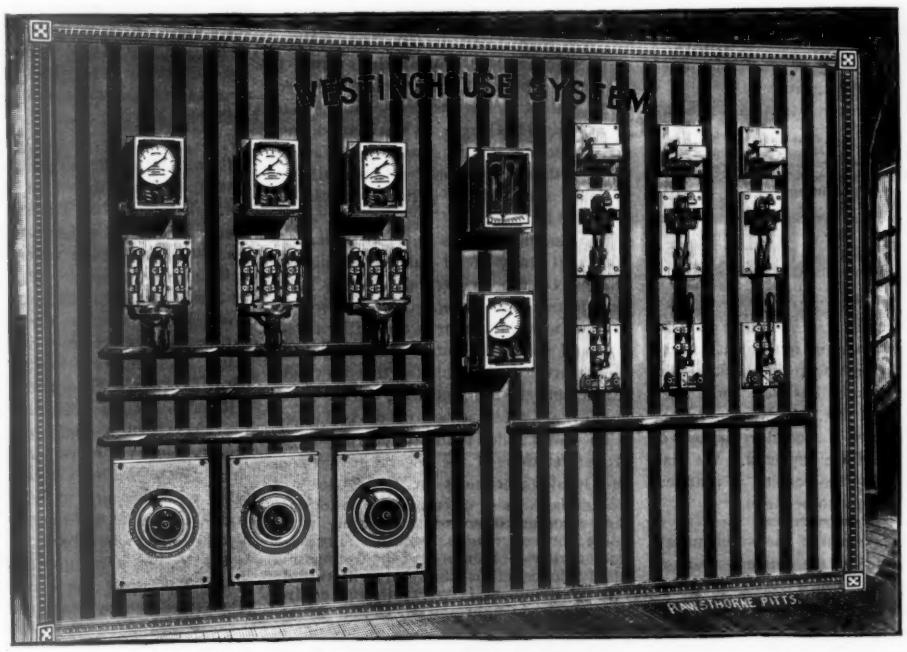

FIG. 3.—WESTINGHOUSE SWITCHBOARD.

Carhart-Clark Standard Cells.

Considerable attention has recently been given by electricians to the subject of standard cells, as such an instrument is indispensable for use in calibrating voltmeters and in all cases where an absolute standard of E. M. F. is necessary. Prof. H. S. Carhart, of the University of Michigan, devoted a large amount of time to the subject, and about two years ago brought out the Carhart-Clark standard cell, which has been extensively used with most excellent results. By a special process Professor Carhart makes these cells so that they can be carried in the pocket or sent from place to place without any deterioration, so that they are perfectly portable. Another remarkable feature of this cell is its very low temperature coefficient, which has been reduced to .00038, this making, for all practical purposes, the temperature change inappreciable. Every cell is accompanied by Professor Carhart's certificate. Messrs. Queen & Company, of Philadelphia, the well known scientific instrument men, have exclusive control of these standard cells.

American Society of Mechanical Engineers.

The twenty-third meeting of the society will be held at Providence, R. I., June 16 to 19. A number of important papers will be read and topical questions discussed, all of a mechanical nature. A programme of pleasant excursions to points of interest in and near Providence has also been arranged.

Los Angeles, Cal.—Rhodes Electric Company; capital, $10,000.

New York City.—The Conduit Wiring Company; capital, $10,000.

Hoboken, N. J.—McLean Engineering Company; capital, $30,000.

Newport, Ky.—Standard Construction Company; capital, $50,000.

Chicago, Ill.—Illinois Pulsion Telephone Company; capital, $500,000.

Natchitoches, La.—The Natchitoches Telephone Company; capital, $5,000.

Cleveland, O.—The National Electric Valve Company; capital, $100,000.

Springfield, O.—The Springfield Electric Railway Company; capital, $50,000.

St. Louis, Mo.—Underground Electric Traction Company; capital, $100,000.

Princeton, Ill.—Princeton Electric Light and Power Company; capital, $15,000.

Paterson, N. J.—Paterson Electrical Manufacturing Company; capital, $100,000.

Danville, Va.—The Virginia & Carolina Heat and Light Company; capital, $300,000.

St. Louis, Mo.—National Automatic Fire Alarm Company of Missouri; capital, $150,000.

Charles City, Iowa.—The Great Western Electrical Supply Company; capital, $5,000,000.

Mt. Pleasant, Pa.—The Mt. Pleasant Electric Light, Heat and Power Company; capital, $5,000.

Chelsea, Mass.—Massachusetts Manufacturing and Electrical Supply Company; capital, $25,000.

Sedro, Wash.—The Skagit Valley Electric Company; capital, $25,000. Incorporators, H. G. Devin, Edwin C. Foltz and John D. Devin.

New York City.—The New York Heat, Light and Power Company; capital, $50,000. Directors, ex-Sheriff James A. Flack, Martin B. Brown, James Stephenson, Wm. S. Newton, Jonathan H. Crane and Charles S. Heins.

Chicago, Ill.—The Zorge Electric Runaway Appliance and Harness Company, capital, $250,000; for the manufacture of harness and carriages and electrical appliances therefor. Incorporators, R. J. Zorge, W. J. Manning and P. V. Castle.

Shamokin, Pa.—Bear Valley and Shamokin Street Railroad Company; to be run with electric power; capital stock, $15,000; and Brady Branch and Shamokin Street Railroad, two and a half miles in length, to be run by electricity; capital stock, $15,000.

New York City.—The Private Line Printing Telegraph Company; capital, $25,000. The directors are William H. Hunt, Eugene Darwin, John J. Walsh, Adolph G. Hummel and Edward J. Murphy, of New York city, and Emil A. Wirsching and Frank A. Graham, of Brooklyn. It is rumored that the object of this incorporation is to supply news to pool rooms.

Sonomish, Wash.—A corporation, consisting of Hon. E. C. Ferguson, E. D. Smith, U. Stinson, F. M. Headlee, J. J. Folstad, H. Blackman and Andrew Haggerty, has been organized to build and operate an electric railway from Sonomish to Port Gardner. Right of way has been granted the corporation for a term of 50 years, by the county commissioners. Capital stock, $100,000.

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As if in fulfillment of our recent remark that many able men were at work on the storage battery, news has just come from Fort Wayne, that Mr. M. M. M. Slattery has about perfected a secondary battery of which great things are expected. We shall await with interest the results of practical tests which are about to be made.

A beautiful specimen of the wood engraving art is shown in the current issue of *Frank Leslie's Illustrated Newspaper*, portraying the Hon. Chauncey M. Depew, the eminent and graceful orator and able railroad president. It is rare, indeed, that so excellent and speaking a likeness is secured, and both the publishers and the distinguished subject are to be congratulated.

An interesting figure is lost to the electrical world by the death of "Uncle" David Brooks, of Philadelphia. One of the pioneers in telegraphic work, he has ever kept in touch with the progress of the electrical industry, and at his advanced age continued to take great interest in everything electrical. Mr. Brooks will be greatly missed by a large circle of warm friends on both sides of the Atlantic.

The National Electric Light Association will make a hit at its next meeting if it secures Mr. Nikola Tesla, of New York, for an evening lecture on his recent work in electric lighting. A rare treat is assured everyone who attends if an address from this talented and progressive thinker is included in the Montreal programme.

The Rapid Transit Commission appointed some time ago to look into the matter of better and quicker means of urban travel for the people of New York rendered a report May 27. A tunnel road is what was practically recommended, and it was resolved "That the motive power for such railway shall be electricity or some other power not requiring combustion within the tunnel," which means, of course, simply electricity.

The beautiful experiments of Mr. McMynn in recording the fluctuations of an alternating current arc, described in Professor Nichols' brief paper published on another page, is profoundly impressive of the marvelous rapidity of photographic action. Think of a luminous body glowing for $\frac{1}{3000}$ of a second or less being reproduced in a band on a traveling screen. During each fractional portion of this short interval, the molecules of the sensitive film make their chemical gyrations and the mass becomes transmuted from one molecular texture to another. During the same interval another transformation no less wonderful is made in the arc itself; particles of carbon are torn from one carbon, flashed into incandescence, projected into space, resolved into vapor and extinguished.

VELOCITIES OF IONS.

In a paper read before the British Physical Society, Mr. W. C. D. Whetham described an experiment to ascertain whether there is any transference of solvent in electrolysis when a porous wall is absent. The author used different colored solutions of the same salt, such as cobalt chloride, in water and in alcohol; the former of which is red and the latter blue. By putting the solutions into a kind of U shaped tube, any change in the position of the line of junction of the two liquids could be measured. Two aqueous solutions in which the union was the same were also tried, one combination being cupric chloride and common salt, and in this case the line of demarcation traversed about seven inches in three hours.

AN ELECTRIC WIRE SYSTEM.

The Government Commission which is preparing a plan for a comprehensive electrical system for the District of Columbia to be submitted to Congress when it meets next December, is making a general investigation of everything connected with the subject, and has accumulated a large quantity of electrical literature.

The Commission has undertaken to make a careful study of all patents having any relation to the matter; all electric light, electric rail road, telegraph and telephone systems now in use, or proposed by inventors, and every manufactured article used in such work. It is predicted that they will recommend the most efficient, durable, economical and safest system yet devised.

The Commission is also to report upon the proper relations of the general government and local government of the District of Columbia to these quasi-public works, and their recommendations will probably be the guide for congressional action. The well known views of members of the commission justify the belief that the report will strongly favor governmental ownership and control of the electric light and all similar works.

The position taken is that all public thoroughfares belong absolutely to the municipality, that it may permit private individuals to use the thoroughfares for their individual purposes of traffic, but that the use of such thoroughfares for the maintenance of electric wires of whatever kind, street railways, gas pipes, and any other works designed for general public service, should not pass out of the control of the municipal authorities.

The decision of this question for Washington will naturally have a great influence on the subject which is being so generally agitated throughout the country. The government telegraph advocates and the socialists generally anticipate that their cause will be greatly strengthened by the forthcoming report of the Commission.

THE PROPHET'S COLUMN.

What is electricity? This question is often asked but, strange to say, rarely with a view to obtaining information. It is frequently used as a poser to floor some loquacious person who has been talking glibly of the subject. One who attempts to answer it seriously is looked upon as presumptuous. But we really know more about electricity than we do about gravity. Every day throughout this broad land school children are giving to their teachers what is considered to be the correct answer to the question, What is gravity? Yet the student who told his professor that he knew what electricity was but had forgotten, has become the butt of a very trite joke. Of the true nature of the mysterious force of gravity little is known.

The recent unparalleled advances in physical science leave us still in the dark as to gravity. It is the same silent never-ending force which keeps the universe in balance. No one has ever been able to screen its attractive effect for even one single second. Go where you will, you cannot escape its force. It causes a stone to fall and a balloon to rise. It makes rain, rivers and mountains, but of its exact nature we know infinitely less than we do of electricity.

Who has ever heard of a wave of gravity, and who can tell the medium by which its power is transmitted from sun to earth? It has been proved that light and electricity are similar manifestations. Waves of light and electricity are now almost tangible every-day things. Electricity can be generated, propagated and suppressed at will, but gravity goes on, always acting, never changing, and successfully defying the power of man.

Many of the actions which are now ascribed to gravity were formerly accounted for in a manner which seemed quite as reasonable as our present explanations. The ordinary suction pump, it is now known, depends for its action upon the pressure exerted on a column of water by the air; but in the time of Aristotle it was explained by saying, "Nature abhors a vacuum." It was observed that space seemed always to be filled by matter, and the moment a solid body was removed its place would be filled by air or water. Thus, when the piston of a common pump was lifted, the water was caused to rise, and the explanation was all sufficient.

It was not until the seventeenth century that the defect in this theory became apparent. The Duke of Tuscany sunk a very deep well and notwithstanding the skill of his best engineers, the water would not rise in the pump much over thirty feet. Galileo, who was then near the close of his career, was appealed to, but he, after remarking that nature did not abhor a vacuum over ten metres, referred the matter to his ablest pupil, Torricelli. The latter reasoned that if it was the weight of the air which sustained the water, that it ought to sustain a much shorter column of a heavier liquid like mercury. He accordingly inverted a long tube filled with mercury over a pan of that liquid, and found that the mercury fell until it came to rest at a height a little over thirty inches, leaving a vacuum at the top of the tube. This upset the Aristotelian doctrine that nature abhors a vacuum and prepared the way for the law of gravitation.

We know many of the laws of gravity, but of the thing itself we know nothing. It may yet be proved that gravity is also an action propagated through the ether. It would thus come under the domain of electricity, which seems destined to absorb all of the sciences. Perhaps, then, when the great secrets of nature are unlocked we may be able to suspend or screen its action at will. This would be a most stupendous triumph of electricity. Until the scoffer can tell what gravity is, let him not ask "What is electricity?" THE PROPHET.

CORRESPONDENCE.

OUR LONDON LETTER.

Electro-metallurgy.—With a capital of £100,000, a limited company has been lately registered under the name of the British Electrolytic Syndicate, to carry on electric metallurgy.

Spain.—The use of the electric light in Spain is progressing greatly. In Valencia there are now 6,000 lamps, in Gijon 1,000, at Albacte 800, at Cuenca 700, at Pampeluna 550 and at Talavera 400.

The St. James and Pall Mall Electric Light Company.—As showing the progress made by this Company, the secretary advises me that for the quarter ending March 31, 1891, the current sold by the company has brought in £9,652; the amount sold in the corresponding period of last year was only £1,818.

Messrs. Easton & Anderson, Limited.—This firm, of 3 Whitehall place, London, and at Erith, advise me they have added a new department to their engineering works at Erith, for the construction of electrical appliances, more especially dynamos and motors. With that object they have taken over the business of Mr. Napier Prentice, of Stowmarket, Suffolk, the patentee of the Whitehall dynamo and motor, and who will have the superintendence of the new department. The firm are now, therefore, in a position to carry out complete installations of the electric light, transmissions of power and other applications of electrical energy.

The Royal Society.—The annual conversazione was held at Burlington House, Piccadilly, under the presidency of Sir William Thomson. There were some very interesting exhibits. Professor Silvanus Thompson showed an ingenious focus measurer for lamp testing; Mr. Killingworth Hedges had his electrical safety valve; Messrs. J. E. H. Gordon and Company showed a Tomlinson regulator for electric light mains, claiming among many other advantages a great saving in fuel; and Mr. Shelford Bidwell had a selenium automatic electric lamp lighter, as well as a selenium alarm to call attention to the accidental extinction of ship's or railway lamps.

Messrs. Priestman Brothers, Limited.—This firm of Hull and 73 A Queen Victoria street, E.C., advise me they have just supplied Mr. George Asplant, of York street, Boston, with one of their three horse-power oil engines and a Taunton dynamo, the latter made by Mr. F. M. Newton, of Taunton, for the lighting up of a patent switchback. The engine and dynamo are mounted upon a bogie fitted with road wheels; the dynamo is driven direct from fly wheel of engine at a speed of 1,300 revolutions, and supplies four arc lamps with a current of six amperes at a pressure of 60 volts, the candle-power of each being about 1,000. Messrs. Priestman Bros., who are now making oil engines from single horse-power to 25 horse-power have supplied a large number for electric lighting among others of that kind, orders having recently been executed for the Victorian and New South Wales governments.

Frankfort Electrical Exhibition.—This exhibition, under the capable organization of Oscar Von Miller, who did so much for the success of the Munich Electrical Exhibition of 1882, has already assured success, and will be formally opened on the 16th inst. The Allgemeine Elektricitats-Gesellschaft and the Maschinenfabrik Oerlikon have definitely undertaken the contract to transmit power electrically from Lauffen to Frankfort, and under heavy penalties must have the work finished by August 15. This important experiment alone is of such vast interest to the whole scientific world as to attract numbers of engineers from all parts. Electric motors, both continuous and alternating current, are to be used for every conceivable industrial purpose, as well as for the driving of the whole of the machinery in the model mine. Among novelties to be shown is a new process for electroplating plaster figures, giving every appearance of solid bronze.

The Royal Naval Exhibition.—This essentially British exhibition was opened last week by the Prince of Wales, and the interesting character of the exhibits, as well as the manner in which the whole of the work has been carried out, has made its success already beyond a doubt. The electric lighting which is most complete and covers the whole of the grounds as well as the covered spaces, has been carried out by Messrs. Siemens Bros. & Company. Even in the model of the "Victory," the ship in which Lord Nelson got his death wound, at the battle of Trafalgar, the four lanterns which were at that time in use have glow lamps placed inside them. The generating plant comprises seven Davey-Paxman locomotive multitubular boilers, working at a pressure of 120 pounds to the square inch, six Williams engines made by Messrs. Williams & Robinson of Thames Ditton; five continuous current Siemens dynamos and one Siemens alternator giving 500 amperes at 80 volts, for a search-light at the summit of the model of the Eddystone lighthouse, which contains an arc lamp said to be the most powerful in the world, and of 5,000,000 candle-power, made and supplied by Messrs. Siemens Bros. & Company. The mains are of the Siemens lead and iron cased type and the lighting is chiefly done by means of new pattern nine ampere Siemens arcs, arranged two in series. Within ten weeks of the signing of the contract the work has been carried out and 10 miles of conductors laid, and 200 arc and 5,000 incandescent lamps installed. The Universal Telephone Company have erected the whole of the telephonic communications by which the various executive offices have been connected with the fire and police stations. Among other exhibitors are Messrs. Ronald & Scott, who show switchboards and an 11-unit dynamo for a search-light over the grand stand; Messrs. Latimer Clark, Muirhead & Company, who supply current for lighting the Camperdown gallery; Messrs. Greenwood & Batley, Limited; the General Electric Power and Friction Company and the Planet Electrical Engineering Company. In most exhibitions at the time of opening nothing is ready, but the Naval Exhibition is a pleasant exception, for everything is in a very complete state.

CHARLES FFRENCH.

London, May 16.

OUR ALBANY LETTER.

The Albany Railway is again getting the position of its lines, which lies in the northern part of the city, on North Pearl street, in condition for motor service. The tracks were laid too late in the fall and sunk when the frost left the ground. They will have to be entirely relaid.

Albany is to Have a New Telephone Exchange, to be erected by the Hudson River Telephone Company. The work will be commenced on the new building very soon. It is to be situated on the corner of Chapel street and Maiden lane. All work must be completed and the building ready for occupancy before January 1, 1892.

Superintendent William C. Miller, of the Watervliet Railway's electric railway lines has resigned, and has been succeeded by Mr. Hawkins. Mr. Miller is one of the cleverest of Albany's electrical experts and has conducted the road in a superb manner for two years. After his resignation he was presented with a gold and silver watch guard and locket by the motormeers and conductors of the road.

A Short Time Since the ferryboat "Chester G. Hain," which plys between Greenbush, Albany and Bath, got tangled in the cable of the Western Union Telegraph Company, at the foot of Westerlo street, Albany. The boat remained fast for several hours, when the wire was cut and the boat towed to the dock. The wire was so twisted in the wheel that considerable difficulty was experienced in removing the obstruction.

On Saturday Morning, May 9, the death of William J. Cull, superintendent of the fire alarm telegraph service of this city, occurred. The Monday previous he had been at work putting up boxes on the Madison avenue extension of the service, when he was seized with a chill. He was shortly afterward taken with pleuro-pneumonia. He was delirious until his death occurred. William J. Cull was born in Brandon, Vermont, in 1832, and came to this city when he was 21 years old. He at once entered the telegraph business, securing employment with the Albany, Buffalo and New York Telegraph Company, with which James D. Reed, at present Consul to Scotland, was connected. In 1869 he built the present fire alarm service, and was made assistant superintendent under Whipple. On Whipple's resignation and removal from the city in 1875, Mr. Cull was promoted to superintendent, a position which he has filled with the utmost fidelity. The disease is believed to have been superinduced by the excessive labor involved in repairing the fire alarm service after the destructive snow storm in February and March. He had brought the service up to a perfect state. In addition, he had invented and applied various electrical devices, which are now in use in many cities.

L. M. W.

Albany, May 30.

OUR BOSTON LETTER.

The Germania Electric Company, of Marlboro, Mass., has established its executive offices in the Exchange Building on State street, this city.

Mr. Timothy W. Sprague, of the Thomson-Houston Electric Company's mining department, has returned to the city after a six weeks' business trip in the South.

The Gorham Manufacturing Company, manufacturers of silver-ware, Providence, R. I., has contracted with the Edison General Electric Company for an isolated plant to have a capacity of 3,000 incandescent lights.

The American Circular Loom Company, of this city, manufacturers of the celebrated "Canvas Jacket" wires and cables, has a large force busily engaged re-covering old wires with this company's patented insulation.

The Lowell Machine Shops, Lowell, Mass., are being fitted up with large overhead cranes which are to be operated by electric power. This will prove a great improvement over the former *modus operandi* of handling large pieces of iron and other metals.

Mr. H. C. Hawks, electrical engineer and contractor, this city, is installing a 500 light incandescent plant at the factory of Mr. L. C. Piser, Shushan, N. Y. Mr. Hawks has another force at work completing the installation of a 1,500 incandescent light plant at Manchester, N. H.

The Oneco Manufacturing Company, New London, Conn., is increasing the lighting capacity of its station by the addition of a 650 light (alternating) dynamo. The new machine will give a total of 2,500 incandescent (16 candle-power) lights. The company has 100 arcs in operation.

The Washburn & Moen Manufacturing Company held its annual meeting Tuesday, May 26, at Worcester, Mass. The vacancies caused by the death of P. L. Moen, late president and treasurer, were filled as follows: William E. Rice, president of the Worcester Wire Company, was elected president and Philip W. Moen treasurer. These other officers were elected by the directors: Vice-president, Charles F. Washburn; clerk, George T. Dewey; general manager, P. W. Moen; general superintendent, F. H. Daniels.

W. I. B.

Boston, May 30, 1891.

OBITUARY.

David J. Hobart, general manager of the Mexican Telephone Company, died suddenly in the city of Mexico, on May 22, of inflammation of the kidneys, superinduced by a severe attack of "la grippe." He leaves a widow and daughter. The death of Mr. Hobart is a great loss to the telephone company, as he was an honorable and exceedingly capable and energetic man.

Mr. Edwards H. Goff died at his home in this city on Thursday of last week from the effects of the grip. Mr. Goff was for many years a prominent factor in electrical circles as the president of the American Electric Manufacturing Company, which finally failed. More recently he became interested in the export business with the countries south of us, and it is reported died in poverty at a time when in a few weeks he would have been a rich man. Mr. Goff was a remarkable man—restless, energetic and scheming; a man of plausibility, with many well wishers, but few confidants. At one time he is supposed to have made a considerable sum of money, but it soon disappeared in some of the many unprofitable schemes which he endeavored to promote. The funeral occurred last Sunday, the remains being interred at Woodlawn cemetery.

Mr. David Brooks, the widely known electrician and inventor of the Brooks underground system for electric wires, died at his residence in Germantown, Pa., on Saturday night, May 31st, of pneumonia, aged 72 years. Mr. Brooks was born at Brooksvale, Conn., in 1820. In 1845 he engaged in the construction of telegraph lines, and was connected with putting into operation the first commercial line in America after the Baltimore line to Washington had been established. Mr. Brooks extended a line from Lancaster to Harrisburg and received the first message sent over it. A year later he constructed the line of the Atlantic and Ohio Company between Philadelphia and Pittsburgh. In 1851 Mr. Brooks went to Mexico, and there built the first telegraph line in that country, between Vera Cruz and the City of Mexico. Upon his return in the following year he was employed by the Pennsylvania Railroad to manage its Philadelphia and Pittsburgh lines, and in 1854 made superintendent and manager of the Atlantic and Ohio Telegraph Company. His system of placing wires underground is widely known, and is in extensive use in England. Mr. Brooks was a very agreeable gentleman, esteemed by all who knew him.

Meeting of the Westinghouse Electric Company.

The meeting of stockholders of the Westinghouse Electric and Manufacturing Company at Pittsburgh, called for June 1, was adjourned until Tuesday, June 23.

Mr. George Westinghouse, Jr., president, was absent, but a communication was received from him stating that over 50 per cent. of the outstanding stock had been surrendered to the Mercantile Trust Company, and it was necessary to postpone the meeting to the date stated in order that the shareholders who have not yet turned in their stock be given additional time to participate in the reorganization.

LITERARY.

We have received the "Third Annual Report of the West Virginia Agricultural Experiment Station" to the Governor and Legislature for 1890.

A never-failing charm of *The Ladies' Home Journal* is that it is always abreast of the season; somehow it presents just the things one wants most to see at the particular time it comes out; this seems especially true of the June number.

The Annual Register of Purdue University, Lafayette, Ind., for 1890-91, has come to hand. A good course in electrical engineering is laid down. A fine new building, containing experimental laboratories, is devoted to the use of students in this course.

We have received from Mr. W. J. Richardson, of Brooklyn, a pamphlet, entitled, "What is the Truth About the Trolley System for the Propulsion of Cars in City Streets?" It is a missionary tract designed to make converts to the trolley system and contains convincing arguments.

Scribner's Magazine for June continues the notable series on "The Great Streets of the World," and "Ocean Steamships." Francisque Sarcey being the author of the article on "The Boulevards of Paris" and William H. Rideing contributing the paper on "Safety on the Atlantic." The illustrations in both groups continue to be very rich, and appropriately supplement the text, adding to its significance and picturesqueness.

The opening poem in the June *St. Nicholas* is by Mr. C. P. Cranch, whose "Last of the Huggermuggers" will be recalled by the fathers and mothers of the present generation of the magazine's readers as one of the greatest delights of their childhood. The present poem is a delicate, graceful fancy, and has been appreciatively illustrated by R. B. Birch, who has drawn a frontispiece and two smaller pictures for it.

"American Electrical Directory for 1890-91." published by the Star Iron Tower Company, Fort Wayne, Ind. This is the fifth issue of this well known and valuable work. The size of the book is the same as last year, except that it contains about 600 pages. The table of contents refers to complete information regarding electrical associations, State associations, electrical clubs and societies, rules and requirements of seven boards of fire underwriters, complete lists of central stations and electric railway plants in the United States, Canada and Mexico, and a large number of tables and formulæ selected with special regard for the needs of station superintendents and managers. The directory is something that no electrical company can afford to be without, and to many individuals it should be almost indispensable. Our endorsement of the previous issues of the American Electrical Directory may be applied to the volume at hand.

FINANCIAL.

Closing quotations of electric stocks, from F. Z. Maguire & Co., Electrical Securities, 18 Wall street, N. Y., Friday, May 29, 1891. New York, Boston and Washington Stock Exchanges.

NEW YORK.	
Western Union Telegraph Co.	80
American Telegraph & Cable	83
Central and South American	135
Mexican	200
Commercial Cable Co.	105
Postal Telegraph Cable	30
Edison General Electric Co.	101½
" " Deferred	
Consolidated Electric Light	
Edison Electric Illuminating Co.	76
United States Electric Light	30
North American Phonograph	
BOSTON.	
Thomson-Houston Electric Co.	43
" " " Preferred	23½
" " " Series C	8¾
" " " Series D	7
" " International Co.	
" Welding Co.	
" European Welding Co.	60
Ft. Wayne Electric Co	12½
Westinghouse Electric Mfg. Co	13⅞
Detroit Electrical Works	
TELEPHONE:	
American Bell	198
Erie	48
New England	50
Mexican	1.22½
Tropical American	
MISCELLANEOUS:	
Edison Phonograph Doll	.50
WASHINGTON.	
Pennsylvania Telephone	25
Chesapeake and Potomac	61⅞
American Graphophone	5¾
United States Electric Light (Wash'ton)	158
Eckington and Soldiers' Home Electric Railway	49½
Georgetown and Tennallytown	57

Telephonic News

*** The Hudson River Telephone Company are considering the advisability of extending their line from Johnstown to the East Canada Lakes, *via* Rockwood and Newkirks.

*** The Kansas City, Mo., board of public works will soon pass upon an ordinance authorizing the Missouri and Kansas Telephone Company to put its wires underground. The board will probably recommend that the company be granted a franchise for a period of 30 years to occupy the streets of the city with conduits. It will be required to provide free of cost to the city separate conduits for the telephone wires used by the police and fire departments.

A Maine Power Plant.

The Maine Electrical Improvement Company have secured the contract for the reconstruction of the power plant of the Brunswick Light and Power Company, at Brunswick, Me. This plant is located on an island in the Androscoggin River. The island is a part of a rock formation in the bed of the river, forming one of the most beautiful cascades to be found upon the Androscoggin River which is noted for its many water-falls. Owing to the abundance of water power available and the advantageous position of this plant, an unlimited amount of power at a nominal cost can be secured for the uses of the many enterprises for which Brunswick is fast becoming prominent. The variation in water level of the Androscoggin River during the different seasons of the year is slight, and, therefore, the power secured therefrom is practically constant for all seasons.

In a place such as Brunswick, located, as it is, within a stone's throw of Casco Bay, which is one of the finest Summer resorts upon the Atlantic coast, convenient to Portland, Bath and other of the principal points in Maine, this electrical enterprise cannot help but be a success, and the Maine Electrical Improvement Company are, indeed, fortunate in securing so valuable a contract, embracing, as it does, a combination of electrical, mechanical and hydraulic engineering.

This company has entered the electrical arena with a complete and well equipped organization for the purpose of engaging in engineering enterprises of every character connected with modern electrical developments. The main office is at Brunswick, Me., under the management of Alexander Henderson, the president, and James L. Doolittle, as secretary and treasurer, with a general business office in the "Electrical Exchange," New York city, under the management of Thos. J. Fay.

The Worcester, Leicester and Spencer, Mass., electric railway is expected to be running by the middle of July. It saves 10 miles and 25 cents on each trip over the B. & A. R. R. charges and makes 11 trips each way per day, instead of four as by the steam cars.

A Photographic Study of the Electric Arc.

BASED UPON EXPERIMENTS MADE BY MR. J. C. M'MYNN.—READ BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, NEW YORK, MAY 20, 1891, BY EDWARD L. NICHOLS.

At the last general meeting of the Institute, Mr. Louis B. Marks read a paper on the electric arc, which dealt with the performance of commercial lamps in the continuous current circuit. The present paper is a preliminary report of a similar line of work now being carried on under the writer's direction by Mr. J. C. McMynn, the subject of the investigation being the alternating current arc. When the research in question is completed, Mr. McMynn will publish the results in full; but, since his report may not be ready for several months, it seemed desirable that I should lay before the Institute at this meeting certain points which have already been established.

The alternating current arc and the continuous current arc afford two entirely distinct fields of investigation. Candle-power, distribution of light, quality of light, temperature, efficiency, resistance, electromotive force necessary to maintain the arc, performance of the carbons under varying conditions; all of these are questions concerning which we have abundance of experimental data, so far as the continuous current arc is concerned. In the case of the alternating arc, however, these and many other points are still to be determined.

The arc lamp, fed by alternating currents, invariably hums and sings. The note, which is not to be mistaken for the hissing which we hear from continuous current lamps that are burning under improper conditions, possesses a definite pitch, determined by the rate of alternation of the dynamo. That the note is not due to the mechanism of the lamp itself is readily shown. The Jablochkoff candle, which is devoid of all mechanism, sings as merrily as the lamp with solenoid regulator; any form of hand lamp will do the same. I do not remember having seen any definite statement concerning the source of this humming noise, nor any satisfactory discussion of the question. My attention was first brought to the very obvious explanation of the phenomenon by the study of certain curves of electromotive force obtained by Messrs. Archibold and Teeple in the course of an investigation of the alternating discharge between a ball and point.* These curves have recently been published. I reproduce one of them for the purpose of elucidation.† This curve was obtained by the well known method of instantaneous contacts. The circuit under investigation was the high tension secondary of an induction coil, actuated by an alternating current dynamo, the electromotive force of which followed the law of sines closely. In the circuit were placed a ball and point, the air space between them being such that the discharge would take place in one direction only, from ball to point. It was established by the use of a revolving mirror that an arc existed only during that part of each cycle represented by the horizontal portion of the curve. (*a*—*b*, Fig. 1.) Shortly after this curve had been obtained, the curves of Messrs. Tobey and Walbridge, illustrating the performance of the Stanley arc lighting dynamo, appeared.‡ It will be remembered by those who heard their paper read before the Institute, that this machine, which gave very nearly the sine curve of electromotive force when working through non-inductive resistance, showed curves very widely removed from that form when arc lamps were in the outer circuit.

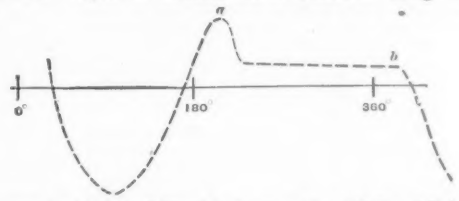

FIG. 1.—From Archbold and Teeple's thesis on the "Ball and Point" effect

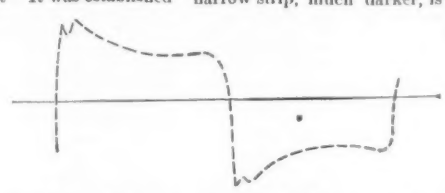

FIG. 2.—From Tobey & Walbridge's paper on the Stanley Arc Lighting Machine

Fig. 2 contains the curve of the arc lighting machine when five lamps were in circuit. The relation of this curve to those obtained with the ball and point is evident. Here, also, the variation of the curve from sinusoidal form is to be ascribed to the periodic formation and breaking down of the arc, which happens twice in every complete cycle, instead of once, as in the case of the "one way" discharge of the ball and point phenomenon.

After studying these curves it seemed to me unquestionable that the humming of the alternating arc is due to the rapid periodic extinction and re-establishment of the discharge, the effect being similar to that observed in singing flames. When, some months later, opportunity was found of viewing the image of the arc of an alternating current lamp in the revolving mirror, I was prepared to witness the extinction of the arc during a definite part of each alternation. I do not know whether any members have not been noted. Of the many negatives already obtained, a few characteristic forms are given in the accompanying plates.

Figs. 3, 4, 5 and 6 show the results obtained with plates moving in a horizontal direction, at right angles with the axis of the carbons of the lamp. Fig. 3 is an enlargement of one of the first negatives taken. The speed of the plate was moderate, the size of the image smaller than the arc itself. The plate contains but little detail. The arc itself. This region, however, is not uniform. It consists of alternate patches of purple and black, which mark the intervals during which the arc exists and is extinct.

Mr. McMynn's first step in the investigation which it is my purpose to discuss in this paper, was to photograph the arc under conditions which would bring out this phenomenon. A camera with long bellows was set up near the lamp, the distance from plate to lens and from lens to lamp being such as to give a somewhat enlarged image of the arc. In the focal plane an opaque screen was mounted, which contained an opening just large enough to receive the image of the carbon points. The apparatus having been adjusted, a sensitive plate was driven past the aperture at high speed. The photographic image differed from that observed in the revolving mirror chiefly in the relative brightness of the arc proper, and of the incandescent carbon of the points. To the eye, the latter is the dominant feature; whereas, the *actinic* image of the arc far exceeded in intensity that of the carbons.

These photographs establish the intermittent character of the alternating arc beyond question. They also exhibit in a new light many interesting properties of the arc, some of which are already well known, while others have not been noted. Of the many negatives already obtained, a few characteristic forms are given in the accompanying plates.

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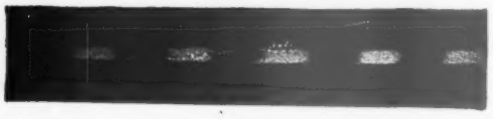


FIG. 3.—Alternating Arc. [Movement of plate horizontal.]

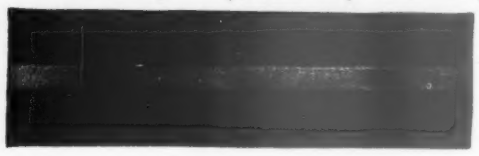


FIG. 6.—Alternating arc. [Movement of plate horizontal.] High speed.

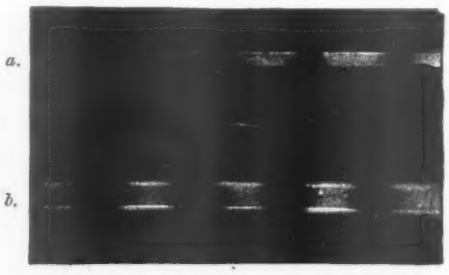


FIG. 4.—Alternating arc. *a.* Long arc (58 volts). *b.* Short arc (43 volts) [Movement of plate horizontal.]

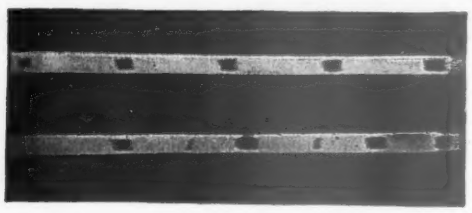


FIG. 5.—Alternating arc. [Movement of plate horizontal.]

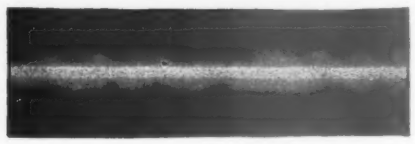


FIG. 12.—Continuous current arc. [Movement of plate vertical; arc in strong magnetic field; arc flaming.]

FIG. 7.—Alternating arc. [Movement of plate vertical]. *a.* Showing oscillations due to earth's field. *b.* Showing oscillations in a stronger field.

* See Archibold and Teeple; Thesis in MS., Library of Cornell University, 1889.

† See "The Alternating Electric Arc between a Ball and Point." *American Journal of Science*, Vol. 41, p. 1.

‡ Tobey and Walbridge; *Transactions*, Vol. 7, p. 367.

* Wiedemann; *Elektricitat*, 4, p. 855.

† Joubert; *Journal de Physique*, Vol. 9, p. 300.

carbons do not appear at all in the photograph, which shows little besides the periodic interruption of the arc. In later negatives the size of the image was greatly increased and the plate was driven much more rapidly through the field. In many instances two or more successive exposures were made upon the same negative. Inspection of Figs. 4, 5 and 6 shows that the greatest intensity resides neither in the arc itself nor on the incandescent carbons, but in a narrow region just at the ends of the arc. In this region, which, doubtless, is that where the so-called "contact resistance" of the arc occurs, the illumination is sometimes intermittent, as in Fig. 4; sometimes nearly uniform, as in Figs. 5 and 6. The relative width of the intervals of darkness and of light is also seen to vary greatly under conditions not yet determined. Fig. 6 represents the highest rate of speed given to the plate in any of these exposures. The image of a single alternation was in this case extended almost across the plate. No new features were brought to light, however, by this process of magnification.

Figs. 7, 8, 9, 10, 11 and 12 were obtained by driving the plate vertically through the field, parallel to the carbons. An unlooked-for feature of all these plates was the oscillation of the arc from right to left in synchronism with the alternation period. Mr. McMynn suspected this vibration to be due to the action of the earth's magnetic field.* He was able to verify his view by comparing photographs made with the camera placed with its optical axis in the meridian with others in which the arc was viewed from the east or west. The disturbance was most marked in the former position and disappeared almost entirely from negatives taken in the latter. This point is well illustrated by Fig. 8 (*a* and *b*), which shows the image obtained from the north and from the east. The lamp in this case was supplied with cylindrical carbons. All the other photographs represent the arc between flat carbons. In a strong field, produced by placing the arc nearly between the poles of a horseshoe magnet, the lines of force being perpendicular to the axis of the lamp and parallel to that of the camera, the vibratory effect was much increased. (See Fig. 7, *b*.) The bearded appearance of the arc in Figs. 9, 10 and 11 is common to all the negatives taken while the arc was in the strong field. The spines are supposed to be the paths of very minute and highly incandescent particles, expelled from the arc at a considerable velocity under the action of the magnetic forces. A continuous current arc, also in a strong field, the conditions being as nearly as possible those under which Figs. 9, 10 and 11 were taken, gave a negative of which Fig. 12 is a very imperfect representation. The arc was flaming, and it will be seen that while the path of the arc itself is an unbroken, straight trace, the flames, which show themselves to the right and left hands, are irregularly intermittent. The negative shows, moreover, that the flame to the right hand, in this figure, is finely striated, reminding one of the image of a hissing, sensitive gas flame, as the latter appears in the revolving mirror. This vibration, which must represent a pitch of several thousand vibrations per second, is in all probability the cause of the hissing of the arc.

In this brief discussion I have left untouched many points which will suggest themselves to those who study Mr. McMynn's photographs. The interpretation of many of the features of these plates is at present rather obscure, but it is hoped that experiments now in progress will add something to our present knowledge of the phenomena connected with the alternating electric arc.

* It should be noted that Casselmann, as long ago as 1844, described the deflecting action of the earth's field upon the continuous current arc. (See *Poggendorff's Annalen*, 63, p. 588.)

How the Arc Light Affects a Hub Reporter.

If you ever observed it, the electric light is responsible for many grotesqueries nightly painted on respectable walls and matter-of-fact sidewalks. Shadows are only shadows, but they give one the shivers sometimes, especially at a late hour, when honest folk are supposed to be in bed. Giants of despair then stretch out long arms at the corners of silent streets, and strange profiles are thrown against the unconscious houses, and weird traceries of dancing branches make the pavement rise and fall in a style that must puzzle a person who knows he is sober. Alone, without the presence of humanity, these electric shadows lend the sleeping city a mystic animation that even conventional moonshine fails to dispel. The sputter, the swish of the lights, too, adds to the uncanny effect, and their fluctuations would in time drive the sane mad, if thought was taken of them. Luckily, man can accustom himself to almost anything civic, and so he passes on his way indifferent to sight and sound of electricity. If he is observing and imaginative, these shadows do not escape his notice. —*Boston Globe.*

Electric Discharges in Vacuo.

In a communication to the British Physical Society, read during its late visit to Cambridge, Prof. J. J. Thomson described some interesting experiments in the electric discharge in vacuum tubes.

The phenomena of vacuum discharges were, he said, greatly simplified when their path was wholly gaseous, the complication of the dark space surrounding the negative electrode and the stratifications so commonly observed in ordinary vacuum tubes being absent. To produce discharges in the tubes devoid of electrodes was however not easy to accomplish, for the only available means of producing an electromotive force in the discharge circuit was by electro-magnetic induction. Ordinary methods of producing variable induction were valueless, and recourse was had to the oscillatory discharge of a Leyden jar which combines the two essentials of a current whose maximum value is enormous, and whose rapidity of alternation is immensely great. The discharge circuits, which may take the shape of bulbs or tubes bent in the form of coils, were placed in close proximity to glass tubes filled with mercury which formed the path of the oscillatory discharge. The parts thus corresponded to the windings of an induction coil, the vacuum tubes being the secondary and the tubes filled with mercury the primary. In such an apparatus the Leyden jar need not be large, and neither primary nor secondary need have many turns, for this would increase the self-induction of the former and lengthen the discharge path in the latter. Increasing the self-induction of the primary reduces the E. M. F. induced in the secondary, whilst lengthening the secondary does not increase the E. M. F. per unit length. Two or three turns in each were found to be quite sufficient; and on discharging the Leyden jar between two highly polished knobs in the primary circuit, a plain uniform band of light was seen to pass round the secondary. An exhausted bulb containing traces of oxygen was placed within a primary spiral of three turns, and on passing the jar discharge a circle of light was seen within the bulb in close proximity to the primary circuit, accompanied by a purplish glow which lasted for a second or more. On heating the bulb, the duration of the glow was greatly diminished, and it could be instantly extinguished by the presence of an electro-magnet. He had not ascertained the true nature of this effect, but he believed the glow to be due to a combination which might be prevented and facilitated by the action of the magnet causing the density to be different in different parts of the bulb. Another exhausted bulb surrounded by a primary spiral was contained in a bell jar, and when the pressure of air in the jar was about that of the atmosphere, the secondary discharge occurred in the bulb as is ordinarily the case. On exhausting the jar, however, the terminous discharge grew fainter and a point was reached at which no secondary discharge was visible. Further exhaustion of the jar caused the secondary discharge to appear in the jar outside the bulb. The fact of obtaining no luminous discharge, either in the bulb or jar, the author could only explain on two suppositions, viz, that under the conditions then existing the specific inductive capacity of the gas was very great, or that a discharge could pass without being luminous. The author had also observed that the conductivity of a vacuum tube without electrodes increased as the pressure diminished, until a certain point was reached, and afterwards diminished again, thus showing that the high resistance of a nearly perfect vacuum is in no way due to the pressure of the electrodes. One peculiarity of the discharges was their local nature, the rings of light being much more sharply defined than was to be expected. They were also found to be most easily produced when the chain of molecules in the discharge were all of the same kind. For example, a discharge could be easily sent through a tube many feet long, but the introduction of a small pellet of mercury in the tube stopped the discharge, although the conductivity of the mercury was much greater than that of the vacuum. In some cases he had noticed that a very fine wire placed within a tube on the side remote from the primary circuit would prevent a luminous discharge in that tube.

In reply to a query by Professor Fitzgerald as to the wire experiment, the author said the action of the wire was probably a question of time, the whole field being thrown on the wire in some way and thus discharged.

b. *a.*

FIG. 8.—Alternating Arc between cylindrical carbons. [Movement of plate vertical.] *a*. Arc viewed from North showing oscillations due to earth's field. *b*. Arc viewed from West.

FIG. 9.—Alternating arc. [Movement of plate vertical; arc in strong magnetic field.]

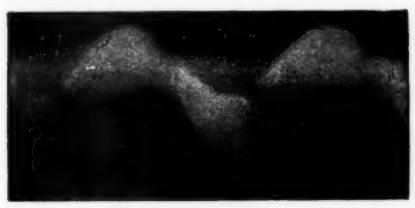


FIG. 11.—Alternating arc. [Movement of plate vertical; arc in a strong magnetic field.]

FIG. 10.—Alternating arc. [Movement of plate vertical; arc in strong magnetic field.]

TELEGRAPHIC

.... A new telegraph cable will be laid by the Government, across Oregon Inlet to Norfolk, Va.

.... The Western Union Telegraph Company has purchased the S. A. & M. telegraph line, 265 miles long. The line will be extended to Montgomery, Ga.

.... The announcement is made that a stock company is to be organized in Cleveland, O., with a capital of $1,000,000 in connection with the Amstutz patent for the transmission of pictures by telegraph.

.... The Hall system of automatic electric block signals has been accepted and adopted by the New York Central and Hudson River Railroad for the protection of the most dangerous portion of their line.

.... A telegraph and telephone line is what the Islesboro, Me., people are talking enthusiastically about. They long to be hitched to the mainland. The last legislature chartered a company and the next thing is to raise the money to construct the line. A meeting of those interested will be held in Belfast at an early date.

.... The Supreme Court rendered a decision last week in the case of the Western Union Telegraph Company *vs.* W. H. Rogers, of Jackson, Miss. Rogers recovered in the lower court a judgment for $800 damages for wounded feelings caused by the delay in delivery of a message announcing the death of his brother. The Supreme Court reversed this judgment, and held that such damages were not recoverable, except in cases of bodily injury, of malice, oppression or wilful wrong.

PERSONAL.

Mr. A. H. Patterson, vice-president and manager of the Phœnix Glass Company, and a prominent member of the Electric Club, of New York, sails June 13 for Paris, accompanied by his wife. Mr. and Mrs. Patterson will sail on the steamer "La Champagne," and will be absent two or three months, visiting Switzerland, Germany, Belgium, Holland and England, and will bear with them the best wishes of a host of friends for a pleasant trip.

Mr. Charles A. Brown, of Chicago, for many years manager of the Western Electric Company, of that city, has formed a partnership with Mr. George Barton, of Chicago, to do a general law business, with a specialty of trade-mark and patent law. The new partnership goes into effect July 1 next. Mr. Brown has the best wishes of the REVIEW for well rounded success in the field of law. His strong potentiality and years of experience and prominence in the electrical field will cause him to be greatly missed by the fraternity generally.

A press dispatch dated San Francisco, May 26, is as follows: "Capt. E. L. Zalinski, of the Fifth United States Artillery, stationed in Presidio, and the inventor of the Zalinski dynamite gun, has been ordered under arrest by General Graham, his commanding officer, for violating orders prohibiting officers or enlisted men from appearing upon the reservation in civilian dress. A court-martial investigation may follow." Captain Zalinski is one of the most valued members of the Electric Club of this city, where he has made hosts of friends. While he is an admirer of discipline, his friends know Captain Zalinski's aversion to red tape and conventionality.

* * The Hot Springs, Ark., street car line is being remodeled to be operated by electric power.

* * The Pottsville, Pa., electric railway is to be extended two miles out to Tumbling Run, a Summer resort.

* * J. D. Wilkes, of Toledo, Ohio, is the new superintendent of the East Side Electric Railway Company, of Brockton, Mass.

* * The Hunt street station of the Cincinnati street railway is nearly completed. It is one of the best equipped stations in the West. They now have 11 Thomson-Houston generators in position, and room for as many more.

* * The Beaver Valley, Pa., street railway was purchased last week by the Central and Metamora Electric Street Railway Companies. It will be called the Beaver Falls Traction Company. The line will extend from Upper Beaver Falls to Beaver, a distance of about eight miles. The new road will use the Beaver Valley tracks through Beaver Falls and New Brighton. The new company expects to have the line in operation by October 1. The Thomson-Houston system will be used.

* * The Poorman mine, Burk, Idaho, is soon to have the largest electric plant for mining in the world. Two 225 horse-power Edison generators, which will be run by water-wheels, will send the current one mile to the mine, where an 80 horse power motor will drive the machinery. The steel drill compressor will be operated by a 60 horse-power motor. The hoist will be run by a 50 horse-power motor. The pump on the 500 foot level, will be run by an 80 horse-power motor. The mine and works will be lighted by electricity.

United Electric Traction Company.

An application has been made to the Probate Court, at Meriden, Conn., to throw the United Electric Traction Company into insolvency by O. H. and J. P. Platt. This is occasioned by a suit against the company by Robert L. Belknap, of New York, who sues for $25,000 money loaned. The case proper will come up before the Supreme Court this week on a foreclosure, and the insolvency proceedings on secondary actions.

National Electric Light Association.

During a meeting of the local committee, held in Montreal last week, the chairman read a communication from His Excellency Lord Stanley, of Preston, Governor-General of Canada. His Excellency expressed his fullest sympathy with the holding of the convention in Montreal, hoping that he would be able to attend in person. After several additions had been made to the many committees already named, the meeting adjourned. The Montreal *Herald* says: "With the extended patronage of His Excellency the Governor-General, the convention cannot now be anything but a grand success."

The Conduit Wiring Company.

This is the name of a New York company recently organized under authority of the Interior Conduit and Insulation Company, whose tubing they will use in any construction work which may be entrusted to them. Mr. Charles J. Klein is president and general manager, and Mr. Solomon Davis is secretary and treasurer, of the new company, whose offices are at 12 West Twenty-ninth street. A general electrical contracting and construction business is the scope of work which will be undertaken. Electrical specialties will be handled, and general superintendence and expert work furnished.

A Study of an Open Coil Arc Dynamo.

READ AT THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, NEW YORK, MAY 21, 1891, BY MILTON E. THOMPSON.

Of all the dynamo machines in use at the present day, perhaps the internal action of none is so little understood as that of the arc lighting machines of the open coil armature class. Much concerning the regulation and general behavior of these machines seems utterly at variance with what one would naturally expect, from a superficial examination of the design and construction, and it was with the idea of throwing some light on this seeming mystery that the investigation to be described was undertaken. In carrying out this work no attempt has been made to determine the efficiency of the dynamo, or to determine an answer to the question—is the machine well suited for arc lighting? The vast numbers of these dynamos in daily use in all parts of the world is a practical answer which must carry more weight than any which might be suggested by a theoretical study of the machine. The experimental work of this investigation was carried out under the direction of Professor Nichols in the laboratories of Cornell University, during the past winter, by the writer with the assistance of Mr. H. J. Hotchkiss and Mr. E. L. Morley, and due credit must be given to these gentlemen for any points of interest which may have been brought out by the investigation.

The object in view was to determine accurately, by taking instantaneous values throughout the revolution, the character of the external and internal currents and electromotive forces.

The capacity of the dynamo in question was about ten arc lamps of 1,200 candle-power.

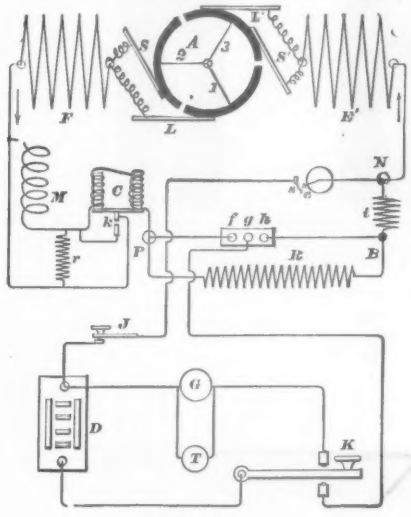


Fig. 1.

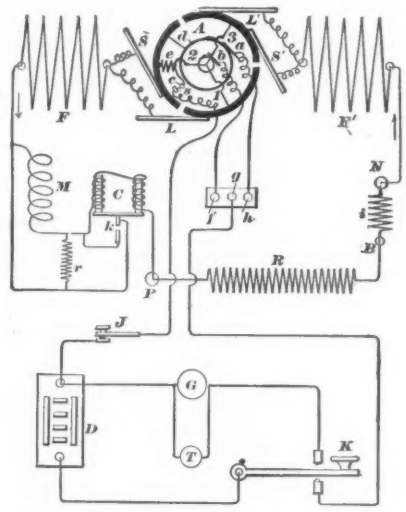


Fig. 2.

In order to carry out this work it was necessary to build a special commutating device of a character somewhat similar to a number of others before used in the Cornell laboratories for taking instantaneous values of current and potential. Professor Ryan was the first to introduce this method at Cornell, which is a modification of that described by Joubert in 1881,* and the device he used was described at length in a paper read before the Institute† on the 17th of December, 1889. The device consisted essentially of a metal tongue mounted upon the shaft of the dynamo and revolving with it, and making contact once each revolution with a small metal spring mounted upon an arm which was so arranged that it could be revolved about an axis coincident with that of the armature of the dynamo and secured in any desired position. By properly adjusting the position of the arm carrying this spring, contact could be made to take place between the spring and the tongue at any desired point of the entire revolution of the armature.

Three sets of curves of exterior current and potential were taken with three different loads upon the machine, and three sets of curves of current and potential through a single coil were taken with the same loads. In order to keep the electromotive force as nearly constant as possible, and prevent variations while a set of observations were being taken, the machine was loaded with a German silver resistance. The loads consisted of about 20, 50 and 80 ohms, respectively, and were equivalent to about three, six and ten arc lamps. The current for all loads was supposed to be practically constant, and an ammeter placed in the circuit showed but little variation from the normal current of 6.8 amperes. A condenser and ballistic galvanometer were used for making the measurements, and Fig. 1 shows a diagram of the connection of the dynamo and also of the measuring apparatus. Referring to the diagram, A is the armature, FF the field coils, M the regulator magnet, C the controller magnet, and *r* the carbon resistance used to prevent excessive sparking at the contacts *k*; P is the positive terminal of the machine and N the negative, R is the German silver resistance which constituted the load for the dynamo, and *i* is a resistance of about one ohm placed in the circuit to serve as a basis for the current measurements. LL and SS are the brushes of the dynamo, which bear against the three segments of the commutator, as shown in the diagram; D is a condenser, K a discharging key, and J a small spring switch; G is a ballistic galvanometer, through which the condenser was discharged, and T is a shunt box for regulating the throw of the galvanometer and bringing it within proper limits. From the negative terminal of the machine, N, runs a wire to the commutating device, *c s*, and from that to the switch J. From the positive terminal P and the binding post B run wires to *f* and *g* of the switch *fgh*, as shown. From *g* of this switch runs a wire to the discharging key K.

Before describing the methods of taking the measurements, it may be well to review briefly the operation of the dynamo and its regulation so far as is apparent from an outside view. The current, leaving the armature through the brushes, L and S, passes through the left field coil and thence through the regulator magnet and controller magnets to the positive terminal, P, of the machine. Passing around through the external circuit, in this case the resistance, R, the current returns to the machine by the negative terminal, N, passes through the right field coil, F, and through the brushes, L and S, to the armature, thus completing the circuit. The regulation of the machine is effected as follows: The controller magnet C is so adjusted, by means of a spring, that a current of 6 8 amperes will just raise the cords of the magnets and separate the contacts, *k*. This permits the current to flow through the regulator magnet, M, and raises the regulator arm, thereby shifting the leading brushes, L and L', forward, and the following brushes, S and S', backward, and thus reducing the potential furnished by the machine. The current is, of course, thereby diminished, and the cores of the controller magnet drop, closing the contacts, *k*, and thus short circuiting and cutting out the regulator magnet. The regulator arm then falls, under the action of gravity, and the leading brushes being moved backward and the following brushes forward, the potential is raised until the current increases sufficiently to once more open the contacts, *k*, and again cut in the magnet of the regulator. The controller magnet acts simply as a relay, and is continually cutting the regulator in and out of the circuit, and in this way the current is maintained constant, regardless of the varying conditions of the external circuit.

Fig. 3.

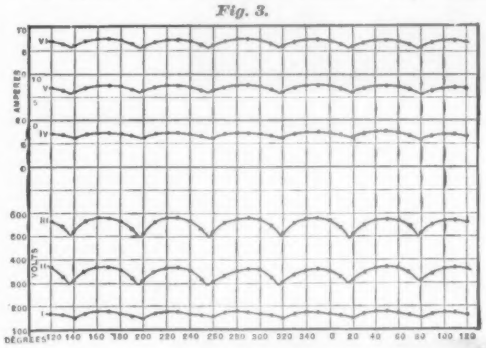
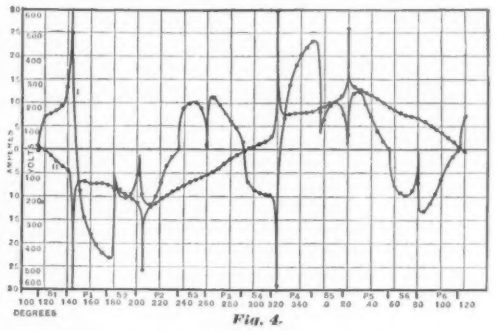


Fig. 4.



During these experiments the regulator was allowed to act just as in ordinary practice, but each load was constant and practically non-inductive. Three sets of curves of external current and potential were taken and the measurements were made in the following manner: The commutating device, *c s*, being secured in a fixed position, *f* and *g* were connected. The discharging key K, being then depressed, switch J was then closed, and in a few seconds the condenser became charged with the difference of potential existing between the terminals of the dynamo at the particular point of the revolution of the armature represented by the position of the commutating device. Switch J being then opened, the discharging key, K, was allowed to rise, and the condenser was thus discharged through the galvanometer, G, causing a deflection which was duly noted. The connections of the switch, *fgh*, were then charged so that *g* and *h* were joined, and in this way the condenser was charged with the difference of potential existing between the points B and N of the external circuit, at the same point of the revolution as the first reading. The condenser was then discharged through the galvanometer and the deflection noted as before.

After moving the contact spring *s* forward 10 degrees, the measurements just described were repeated, and so on until the contact had been moved entirely around the circle.

The condenser and galvanometer being properly calibrated, it was an easy matter to calculate from the data obtained as above, the difference of potential between the terminals P and N, and between B and N, at 36 points of the revolution of the armature. The resistance between B and N being known, the current was readily determined from the fall of potential. The results of these meaurements are shown

* Joubert; Etudes sur les Machines Magneto-Electriques; *Annales de l'Ecole Normale-Superieur*, 10, 46 pp., 1881.

† Transactions, vol. vii., p. 3.

graphically in Fig. 3 and will be referred to later.

After taking curves of the exterior potential and current, the apparatus was arranged for measuring the potential and current in a single coil of the armature. Coil No. 2 was selected as likely to present results nearest the average of all three of the coils, and the apparatus was arranged as shown in Fig. 2. The circuit of the dynamo and its loads were exactly as for the first measurements, and the connections of the measuring instruments were as shown in the diagram. Referring to Fig. 2, *a* is a small brush which bears against a ring *d* secured to the commutator but carefully insulated from it. This ring is connected to the commutator bar of coil No. 2, and thus gives metallic connection with this bar at all points of the revolution. A small brush *b* bears against a similar ring wound round the armature shaft but insulated from it. This last ring is connected to the three inner ends of the three coils, and thus a continuous contact is made with these ends. The outer end of coil No. 2 was disconnected from the commutator bar and a small non-inductive resistance *e* was inserted between the end of the coil and the bar. The junction of the coil and the resistance *e* was connected to the tongue *c* which revolved with the armature shaft. Once during each revolution the tongue *c* made contact with the small spring *s*, from which a wire ran to the switch J and thence to one terminal of the condenser D. Wires ran from brushes *a* and *b* to the switch *f g h*, and from this switch a wire ran to the discharging key K, as shown on the diagram. When *g* and *h* were connected, and keys J and K depressed, the condenser was charged with the difference of potential existing between the ends of coil 2 at the particular point of the revolution represented by the position of the contact spring *s*. The condenser being then discharged through the galvanometer, a measure of this difference of potential was thus obtained. Switch *f g h* was then changed so that *g* and *h* were connected, and measurements then taken with the condenser and galvanometer gave the difference of potential between the ends of the non-inductive resistance *e*, and from this the current in coil 2 was calculated. Readings were taken in this way at distances of five degrees apart all around the revolution, and the results are shown plotted out in Figs. 4, 5 and 6, three curves at three different loads being taken as before. It is not the purpose of the writer to go into the theories of cause and effect as exemplified in these curves, but to simply present them, calling attention briefly to some few of the more noticeable and interesting features connected with them.

Turning now to the results obtained in Fig. 3, curve I represents the difference of potential at the terminals of the dynamo throughout the revolution under a light load, and curve VI is the corresponding current. Curve II is the potential for medium load and curve V the corresponding current, while curves III and IV represent the potential and current at full load. It will be noticed that the curves for medium and full load are practically alike, while the curve for light load differs slightly in its character and is less symmetrical, and its minimum points occur slightly later than in the other curves. The curves of current and potential are practically alike, as might be expected since the self-induction of the external circuit was little or nothing. The curves are all of them about such as would result from a closed coil armature with a six part commutator. It may be well to remark that in taking the observations for these curves, closer readings than are shown were taken near the minimum points, so as to be sure these points were correctly placed.

These curves show that the external current is continuous and much steadier and more uniform than is usually supposed.

Referring to Fig. 4, we find that the state of affairs in a single coil is quite different from that at the terminals of the dynamo. Curve I represents the difference of potential at the ends of the coil throughout the revolution, and curve II is the current in the same coil during the revolution. The curves shown in Fig. 4 were taken with a light load. Figs. 5 and 6 show curves taken with medium and with full loads. For some unknown reason it was found impossible to get accurate readings for the current at full load, and so no current curve is given in Fig. 6. It is probable, though, from the similarity of the current curves at light load and at medium load, that the current for full load differed very little from the other two.

It will be noticed that at all loads the potential changes sign no less than six times during the revolution, and falls to zero, or almost to it, as often as 12 times, while the current reverses but twice during the revolution and for the most part goes through very gradual changes. At the bottom of the figures are lines of spaces showing the positions of the armature during the part of the revolution represented by the curves above them. s_1, s_2, s_3, etc., are the periods of short circuit and p_1, p_2, p_3, etc., are the periods during which two coils are usually supposed to be in parallel with each other and in series with the third coil. There are six periods of each kind in the course of each revolution. Figs. 10, 14 and 18 represent the relative positions of commutator and brushes at the three different loads during the parts of revolution shown at s_1. For the light load this period is about 25 degrees; for the medium load about 10 degrees, and for full load not more than one degree. The periods shown are not the *actual*, but the *apparent* periods of short circuit as it would seem to be from the positions of the commutator and brushes. The *actual* periods of short circuit are somewhat longer, owing to the conductivity of the spark, and last until the spark is blown out. The exact point of the revolution represented by Figs. 10, 14 and 18 is the point 130 degrees, as marked below the curves. Figs. 11, 15 and 19 represent the positions of the brushes and commutator for the parallel periods p_1, or, to give the exact position shown, 160 degrees. Figs. 12, 16 and 20 represent the second short circuit period, s_2, or 190 degrees, and Figs. 13, 17 and 21 show the second periods of parallelism, p_2, or 220 degrees. In all of these figures the relative positions of the coils and poles of the dynamo are also shown, the coils being numbered 1, 2, 3, just as they are on the dynamo. During the entire period represented by each four figures as above, the armature has turned through 120 degrees, or one-third of the revolution, and if we now consider the position of coil 2 changed to that of coil 1 in each figure, our figures will then represent the next third of the revolution. If coil 3 is supposed to occupy the position of coil 1, we shall then have the remaining third of the revolution.

It will be noticed that the more sudden and violent changes of potential occur just as the spark is forming and being broken at the front end of the commutator bar.

In examining these curves of potential it should be remembered that they represent the *difference* of *potential* at the ends of the coil and *not* the electromotive force developed in the coil during the revolution. The sudden and marked changes in current which are shown at certain points of the current curves are selected from a number of readings which showed great variation. In some cases the reading had an opposite value from that shown in the curve, and it seems probable that, all things considered, the average value of these points should be very little, if any, different from the others, and the whole should form a smooth curve without any very sudden changes. In Figs. 10 to 21, the arrow shows the direction of the current in each coil during that particular part of the revolution represented by the figure. In each of these figures a neutral line *n n'* is shown, in passing which the current in each coil becomes zero and reverses. It will be noticed that the direction of the currents in the various coils for the so-called periods of parallelism and short-circuit is quite different from what should be naturally expected and from what has been supposed to be the case in most of the descriptions of the action of this machine. For instance, in Fig. 11, we have the current in coil 1 flowing *toward* the junction of the three wires, showing that a current is flowing from the junction through coil 3 to the left pair of brushes and back through coil 1 to the junction again, or in other words, that coils 1 and 3 are short-circuited upon each other. This state of affairs continues, with the light load, until commutator bar 3 touches the right following brush and short-circuit period s_2 commences. Thus it will be seen that there is no instant during the so-called parallel period when coils 1 and 3 are in parallel and that the *actual* parallelism does not occur until after the beginning of the period of short-circuit. In the case of medium and full loads, however, it occurs at from 10 degrees to 20 degrees before the period of short-circuit. Another point worthy of notice is, that at the first instant of short-circuit, when the commutator bar just touches the following brush, there is no sudden increase of current as would be naturally expected, but the current in the short-circuited coils slowly and gradually increase until the short-circuit is broken by the blowing out of the spark, at which instant the current is a maximum in the coil whose commutator bar is opposite the sparking point, and in the other two coils it is about the same as the normal external current.

In Figs. 7, 8 and 9 are shown curves of potential at the brushes at the three different loads. These curves were obtained from the potential curves of Figs. 4, 5 and 6, by adding together the potentials of the three coils according to their relative positions, and thus obtaining the potential at the brushes. It will be noticed that at all loads the curves fall below zero six times during each revolution, and that the difference in area and consequent effective electromotive force is obtained more by the widening out of the curves than by increase in height. This is what we ought to expect from the change in duration of the short-circuit periods. A comparison of these three curves of potential at the brushes, with the three curves of potential at the terminals of the dynamo, will give one a good idea of the remarkable steadying power which magnets such as the fields of this dynamo exert upon an intermittent current. No further explanation is needed of the fact that this dynamo will not work as a separately excited machine. The whole set of curves will serve to illustrate some of the very remarkable effects of armature and field reactions, and any one sufficiently interested to make a detailed study of them might possibly succeed in bringing out a number of curious and interesting, if not useful, results.

It is to be regretted that time did not permit the measurement of the exact electromotive force developed in a separate coil of the armature, as distinct from the difference of potential at the ends of the coil, and also the measurement of the changes of magnetism occurring in the fields of the dynamo. With the help of this additional data a very complete study of the internal actions of the machine might have been made, and possibly results might have been obtained which would throw useful light upon the interesting subject of armature reactions. The writer hopes at some time in the near future to make a further study of the machine in this respect, and to present any further data obtained in this way as a supplement to this paper.

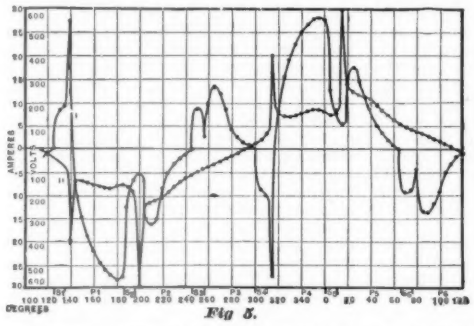


Fig 5.

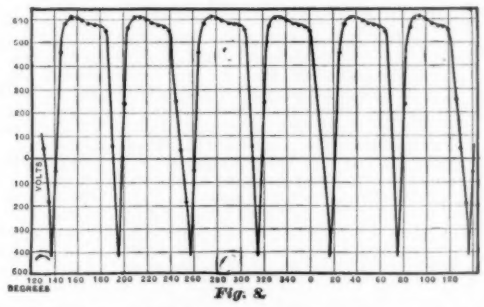


Fig. 8.

Fig. 6.

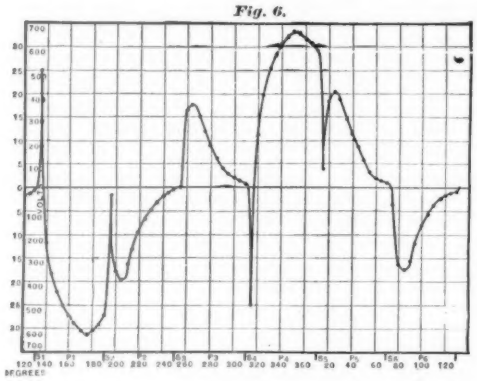
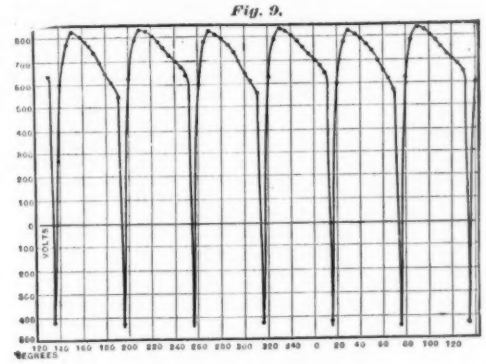


Fig. 9.



Massachusetts Institute of Technology.

We have received an invitation to be present at the graduation exercises of the class of '91, M. I. T. Our wish is that the new bachelors of science may make as much of a success of life as many of their predecessors have done.

ELECTRIC LIGHT NEWS

—— Monterey, Cal., is to have electric lights.

—— Vandalia, Ill., is talking of establishing an electric light plant.

—— Mr. Albert J. Corriveau has secured the contract for lighting the town of Lachine, Canada.

—— The Paris municipality has renewed for 10 years the contracts for the electric lighting of the boulevards.

—— Governor Hill has signed the bill extending the life of the New York Board of Electrical Control for one year.

—— The Beaver Electric Light Company has received the contract for lighting the borough of New Brighton, Pa., with 40 arc lights.

—— The demand for frosted incandescent lamps of the Thomson-Houston type is becoming enormous, and thousands of them are being turned out daily by the Lynn factory.

—— The Massachusetts House of Representatives, on May 22, passed to be engrossed the bill to allow the town of Danvers to maintain and operate a municipal electric lighting plant. There was but slight opposition to the bill.

—— The San Francisco street committee is considering the advisability of having the electric light towers carrying 16,000 candle-power of lamps replaced by smaller masts carrying 2,000 candle-power lights. A better distribution of light is requested by residents of outlying districts.

—— Chief Casey, of the Cambridge, Mass., Fire Department, has received a check for $100 from the Cambridge Electric Light Company, to be devoted to the Firemen's Relief Association, in recognition of the services of the department at a fire at the electric light plant on the 16th inst.

—— The stockholders of the Wenstrom Consolidated Dynamo & Motor Company met in Baltimore, Md., May 20, and elected as directors Enoch Pratt, G. M. Hutton, F. C. Latrobe, E. E. Jackson, Robert Rennert and Henry Janes. At a subsequent meeting of the directors, Enoch Pratt was chosen president.

Considerations Which Should Govern the Selection of a Rapid Transit System.

ABSTRACT OF A PAPER READ AT THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS BY FRANK J. SPRAGUE.

Before considering the current reports of the New York Rapid Transit Commission's deliberations, a general review of the subject may be advisable.

There are two classes of people who are concerned in the final decision made—the public and the capitalists. In order to satisfy, as far as possible, the demands of both, some of which are common, it is well to examine them separately.

To accommodate the public, it is necessary to :

1st. Supply present demands by following, as nearly as possible, the most important existing arteries of travel. An express train on the banks of the Hudson would be of little use to Broadway.

2d. Provide for those future lines of traffic which, other things being equal, will most naturally be formed.

3d. Make the most numerous and convenient connections for existing and projected local and suburban transit lines in directions other than those followed by the main system.

4th. Interfere least with changes in present buildings, or the erection of future ones. In no city in the world is this change more pronounced or continuous.

5th. Cause the least disturbance to, or weakness of, foundations, present or future, and unnecessary displacement of service pipes, whether steam, gas, electric, air or sewer.

6th. Avoid disfigurement of streets and unnecessary appropriation of them.

7th. Inflict the least damage to property, either during construction or afterwards, in operation.

8th. Provide the highest express and way speeds, each on independent tracks.

9th. Attain this last with the least liability of derailment or to other accident.

10th. Provide the easiest access to stations, taking of all trains from one station, transfer from way to express trains and *vice versa*, from up to down trains, or to cross town trains, or other intersecting lines.

11th. Finally, it must be built as quickly as possible, and should possess great flexibility.

To attract capital, the system :

1st. Should afford a reasonable and certain return on the money invested in the near, and a greater return in the remote future.

To do this the road must attract passengers, which it will do by following the main arteries of travel, and by affording increased speed, with increased comfort and safety.

2d. Must be built economically and as cheaply as possible, consistent with sound plans for future growth.

3d. The cost should be calculable with reasonable accuracy. This cost is comprised in a number of elements as follows: Preparation of way—such as tearing down buildings, digging up streets, moving pipe systems, altering sewers, sinking of shafts, etc. Actual construction—such as building of viaducts, erecting superstructures, driving tunnels, laying road-beds. Temporary damage—to and blocking of public and private business and travel during construction. Permanent damage to property—whether caused by proximity of road, noise, dirt or vibration, weakening of foundations or interference with future buildings. Building space taken up—either by roadway, moving trains, or necessary clearance above them. Equipment of rolling stock—less with steam, greater with electricity.

4th. Should be such a construction as to make additional tracks possible, if future demands should warrant it, whether such tracks be parallel to, or intersect with, the main system.

5th. The process of construction should be hampered as little as possible by injunctions or legal complications of any kind.

6th. The place of construction should be such as can be most readily begun, most rapidly carried forward and most quickly enable the road to become a dividend earner.

7th. The franchise granted should be secure from unjust restriction and future interference.

8th. The raising of capital should not be made difficult by the granting of privileges for extension to existing corporations, of such character as to make their competition in the same field. An extension of the "Elevated" up the Boulevard would have their influence on any other system proposed for the same route.

In investigating the various systems it is pertinent to inquire :

When was each proposed?

How comprehensive is its character?

Which presents the most modern and progressive engineering?

Which will best satisfy the future as well as the present needs of New York city?

Which will cost least, be most quickly constructed, and hence most strongly appeal to capital?

To satisfactorily answer these queries there are three things to be determined. They are:

Motive Power.

Method of Construction.

Routes.

In order that the New York Rapid Transit Commission may have the greatest latitude of judgment, these should be determined in the order named, that is, the determination of motive power should precede that of construction, and the method of construction that of route.

Two systems of motive power only are under consideration, steam and electricity, the former a well known agent whose advantages and disadvantages are well known, the latter a newer application of force, one in which the layman is not so well versed, but one whose advantages and possibilities are well understood and most thoroughly relied upon by those who have made it their particular study.

The vital importance of letting the determination of motive power precede that of construction and route will be clearly illustrated by noting the limitations upon construction. There are five general plans which have been proposed.

a. An elevated steel structure, similar in character to the Manhattan system, and occupying the public streets.

b. The viaduct masonry construction similar to some of the London sections of English trunk line systems, the viaduct road of Berlin, or the Broad street section of the Pennsylvania Railroad in Philadelphia, to run through the middle of building blocks, and to span the streets with steel arches.

c. A shallow tunnel made by excavating the streets, removing or diverting the existing system of pipe services of all kinds, running the tracks in one or two tiers, either superposed, or in different vertical planes, the street to be floored over with a steel girder structure. The enclosed track would be something like the Fourth Avenue Harlem Road tunnel except that it would be entirely enclosed.

d. An iron tubular closed tunnel construction, the tubes running at a depth of from 20 to 40 feet below the surface, and built something like the North River tunnel, but individualized like the Suburban and South London road, constructed in London by the Greathead Interests, and opened for regular service last November.

In this system the various tracks would be generally independent, and the way and express routes likewise independent, save at common intersecting stations.

e. A deep rock two track tunnel identical in character with every other rock or mining tunnel with which we are all familiar.

If electricity be adopted as a motive power, the commission will be left untrammelled to determine which of these constructions is preferable.

If steam is adopted, considerations of construction are at once limited to plans *a* and *b*, and even then there exists a limitation in the viaduct system not yet realized, to which I will soon refer.

I think it may be taken for granted, first, that a west side route should come as near Broadway as possible; second, that a four track system is essential, because higher speed and greater capacity are required, and both way and express service must be provided.

An elevated structure necessitates the appropriation of streets already needed for other purposes. If for four tracks in one plane such a system is impossible in most of our streets. It is hardly necessary to further discuss the objection to this system.

A viaduct construction requires for every foot of way, except at street crossings, the condemnation and purchase of property of great value in the business heart of the city, of an aggregate far exceeding the proper cost of road construction. It means the tearing down and re-erection of many buildings, the interruption and cessation of the business carried on, with all the necessary legal complications which will surely follow, thus increasing the cost of construction in an unknown but material way, and it would require extra provision of capital for the purchase and alteration of these buildings.

But, as I have intimated, there is a distinct limitation to this plan in the simple one of motive power. There are two plans of constructing such a viaduct, one by making a clean cut through the buildings, leaving the roadway uncovered, and the other by tunneling through the buildings. If the former plan is adopted there would be thrown away a continuous strip of block space in the most valuable section of the city from 25 to 50 feet in width, according to whether the tracks are in one or two planes, and from 50 to 300 feet in height. Although the value of this wasted space is well nigh incalculable, it is the only plan by which steam could be made available, because if the roadway is covered in the block spaces, and steam be used, the same objectionable features would exist which have given the Fourth Avenue Harlem tunnel so unenviable a reputation, and the damage to property would be even more pronounced. If, however, the viaduct construction were adopted economy would demand the tunneling rather than the cutting down method of getting through buildings. This consideration would then require the abandonment of steam and the adoption of electricity.

But suppose this suggested construction and motive power be adopted in the populous portion of the city, and the street crossings be left open; there would then be that most disagreeable alternation of light and darkness, or of a greater or less degree of light, which is another of the objectionable features of the Fourth Avenue tunnel, and hence the crossings themselves must be enclosed, and with what result? The additional disfigurement of the street may be here ignored; but there would be simply an elevated tunnel of the most costly character, supported on a masonry viaduct, and a system of most questionable financial promise.

In considering an elevated or viaduct structure following the approximate route outlined, it is well to note what obstructions would be met in its course in the lower part of the city.

How, for instance, would such a system cross the Manhattan system at Thirty-fourth, Fifty third, and Sixty-fifth streets? Would a grade crossing be advisable or permissible? Unquestionably not, for the danger of collision and the delays and blocks would at once condemn it. If not a grade crossing, then which road would be uppermost? The Manhattan being already in possession, the new system must do the crossing, and at an abnormal elevation. What would be the effect of the operation of such a road upon the Metropolitan Opera House?

As regards stations, the elevated and viaduct plans require separate up and down platforms, and it would be interesting to inquire how, with the limitations which must exist on roads of this character, it is possible to serve way and express tracks on a common level, except by making them common at the way and express stations. The danger attending this practice must be apparent.

Returning again to the question of motive power, it is important to know what are the objections raised against the use of electricity. About the only one made public is that it has not yet been used on as large a scale as would be required in the proposed system. This reason seems ultra conservatism, and it is to be regretted that on a subject of such vital importance there has not been a more thorough public inquiry made on this subject.

This same view was taken of the application of electricity to street railway propulsion only three years ago. There was scarcely an engineer, a street car builder, a street railway constructor or a capitalist, who did not laugh at the claims which were made for it, and yet in this short time there has been a total revolution of feeling. There is not probably a street railway manager in the United States who does not thoroughly believe that electricity is the present and coming power for street railways, and who, if he were constructing a new road, or re-equipping an old one, would not at once, or in the near future, adopt electricity if he could get the necessary rights to do so; and it should be borne in mind that the equipping of these roads has meant in very many cases the entire rebuilding of the track, the purchase of new cars, the building of costly stations, and in short the investment of a greater capital than had already been invested in the original plant, so that $50,000,000 is a small estimate of the sum which stands invested to-day in this one industry alone.

If, however, the commission is still in doubt, then in order to get a more intimate knowledge of what electricity can do as a motive power, it would seem proper, First, that a time be set apart for the public examination of electrical engineers and contractors. Second, to require a private statement from electrical engineers, confidential if desired, as to any new developments not publicly known. Third, to visit two or three of the prominent electrical establishments to see what has been, is being, and what will be, done in general electrical machine construction. Fourth, to then state what duty would be demanded of electric motors and what guarantees of performance would be required under forfeiture.

If something like this be not done, then I think it safe to say that the rejection of electric motive power will be because of the following reasons :

Its novelty; allowing accidents incident to the early period of its developments to outweigh in importance its demonstrated advantages; a conclusion that it is limited in capacity and development, and lack of information as to its past, present and promised future.

Such a rejection would be upon technical advice relied upon by the commission.

This, it would seem, ought to be that of the Board of Engineers, not the judgment of any one man, because no one has sufficient experience to warrant such reliance upon his dictum in a matter of so grave import, and on a subject to which so many able engineers are devoting themselves, and the development of which has enlisted so many millions of capital.

The motor equipment on, for example, the present London road is composed of 100 horse-power units. That required on elevated railroads is 185 horse-power. Attach four motors of the London type to the same circuit, instead of two, govern them, as is perfectly feasible, by the same controlling device, and they will outwork any elevated road engine. Increase the dimensions in these machines one-third only, and two of them will do the work of this engine. Duality may be objected to, but it should be borne in mine that duality of engines is absolutely necessary in a locomotive for successful operation. It is not essential in an electric motor equipment, although advisable for traction purposes. But for that matter, double the dimensions of a London machine and it alone will outwork the two cylinders of the elevated locomotive.

Perhaps one of the most telling arguments in favor of electrical propulsion is the fact that in London another underground road, to be operated by electricity, is about to be constructed on plans already approved by a Parliamentary committee. This road is about six miles long and connects the West End with the city. It forms approximately a diameter of the oval described by the present steam underground railways. A 5,000 horse-power station at the suburban end of the line will supply the current. The trains are to consist of six cars seating about 340 persons and will weigh, with the electric locomotives, 120 tons. The average speed is to be 14 miles an hour, including all stops, with a maximum of about 25 miles an hour. Since this weight, power and seating capacity, exceed that now common on the elevated railroads it is a somewhat practical answer to the objections made on this point.

There have been no demands for a 2,000 horse-power steam locomotive, but there is not a builder in this country who, given suitable gauge of track and allowed dimensions of engine, would hesitate a moment to build a locomotive of that capacity.

So, too, with electric motors. Given the incentive, and before the first foot of roadway is ready on the proposed rapid transit system of New York, a 200 horse-power electric locomotive will be built which will, under forfeiture, outwork any elevated road engine for speed, pulling capacity, steadiness of work, time of operation and continuous mileage.

This statement is made from personal knowledge, and with an individual willingness to assume the risk.

Break a single part of the many in a locomotive and it is helpless. Break many of certain parts in an electric motor and it will, although crippled, still operate. In short, the near future will make the electric motor the most reliable machine constructed for power purposes.

What is the experience of other large cities in this matter of rapid transit?

In London the same interest which built the Greathead tunnel has been granted Parliamentary rights for extensions, ordinarily most bitterly fought against, with an almost unexampled unanimity.

Paris is considering seriously the question of a great metropolitan underground electric system.

Boston has been advised, after most careful investigation, that the only proper system for the business portion of the city is an underground electric system.

As regards New York, while unnecessary delay is to be avoided, it is certain that no present delay is half so serious in its consequences as the adoption of an inferior plan by reason of immature consideration, lack of knowledge or information, or in response to popular clamor.

The demands of to-day can be best served by plans to meet the future wants of New York as well, while the needs of the future cannot be properly provided for by planning for present limitations.

As I close this paper there comes news of most reassuring character, for the chairman of the commission is reported in Tuesday's *Commercial* and in Wednesday's morning papers, as stating in the most emphatic manner that the commission is planning for future New York, and that it will, under no consideration, even consider the plans of the elevated railroad until after it has determined upon a route to satisfy the demands of that future.

This statement of the chairman is most opportune and will go far to allay the anxiety which has been honestly felt by those who await the result of the commission's deliberation.

It is also stated, presumably on the same authority, that a system and west side route from the Battery to the Harlem river, has been definitely settled, part underground and part viaduct, and the announcement of this decision will be definitely made next Tuesday. If so, then it would seem that electricity has now the victory, and the particular method of construction and the route selected will form the subject of discussion.

Discussion on Prof. Francis B. Crocker's Paper on "The Perfection of Stationary Electric Motors."

Prof. W. A. Anthony: Professor Crocker certainly has not laid too much stress upon obtaining a large surface of contact between the wrought and cast iron in forming a joint, and even in making a joint between two wrought iron pieces, it seems to me that a large surface of contact is needed also, for any amount of machine work that it is practical to do economically does not produce anything like the surface of contact that you would have in a field magnet made up of one piece. For instance, suppose the pole piece and the core were joined by means of a joint in this case—I venture to say that with any joint that it would be practical to make there economically—you would not have one quarter of the surface of contact between the two metals that you have when you make it of a solid piece.

Mr. W. J. Hammer: This question of contacts in the fields of a motor calls to my mind some experiments I made at one time in connection with one of the old Edison Jumbo machines. As many of the gentlemen here will probably remember, the old machines had a large number of fields. It used to be a very difficult thing to get perfect contact, although the surfaces were polished. When the cores were bolted together there were consequent poles generated, and I made some experiments at one time with a field explorer made from an incandescent lamp. I brought it up to high candle-power—until there was this blue fluorescence all through the globe which is very sensitive, and I found it was a very sensitive field explorer, and showed not only the strength of the field in different parts of the poles, but also the magnetic leakage. In passing it over the pole pieces of the machine I found out that there was quite a difference at the points of contact. They formerly had a double row of fields down below with three cores, and where these bolts were put in the surfaces were polished very brightly and tightly fitted together. In some of these places where the bolts were not tightened up I found considerable difference in the lines of force and strength in the consequent poles. There was considerable difference in the efficiency of the fields by tightening up those joints, and that was indicated by this sensitive form of field explorer.

Prof. Elihu Thomson: With reference to the contact between the cast iron and the wrought iron, Professor Crocker is certainly right in saying that there must be a large amount of surface contact, and that the difference between those surfaces must be a minimum; that is, they should be in very close contact. Now, in order to get the same amount of surface, there would have to be a flange, or something of that kind. That would occupy a great deal of space. It seems that the advantage that he pointed out then would be that he takes that flange, as you might say, and puts it in a hole and takes out some of the cast iron. In that way with the metal represented in Fig. 4, he gets the same amount of surface and gets the same close contact, and yet occupies less space, simply because he takes out some of the cast iron and puts the wrought iron in there. Of course, by means of inserting those—for instance as you put a wheel on a car axle—the contact would be closer than you could ever get by any bolts. I do not know whether that is the way they were fastened in there, by the principle of contraction by cooling, or whether they are simply driven in.

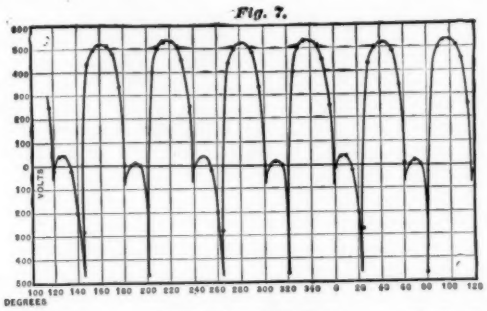
Mr. C. O. Mailloux: It might be well to state, in connection with this joint matter, that it was carefully and somewhat exhaustively gone into in Europe about a year and a half ago, the results of which investigation were reported in the scientific press, and it was found that the character of the contact made a great difference so long as you confined yourself to rather low densities—low degrees of saturation of magnetism. But when once the density became large, the apparent effect or defect of joint did not make very much perceptible difference; that so long as you had low densities it made considerable difference. But when once you reach saturation, or any degree approaching thereto, it practically didn't make very much difference.

Professor Crocker: I simply stated in a general sort of way that a good joint was desirable, which I think no one will deny. Furthermore, the resistance of the joint which I think is properly stated to be equivalent to an air-gap of half a thousandth of an inch, or, as it is expressed by Thompson in his recent book, as equivalent to so much of the iron circuit—the advantage of expressing it in terms of air-gap, is, that air has the permeability of one, and is definite. But I spoke of the necessary surface of contact between wrought and cast iron. If cast iron has 50 or 60 per cent of the permeability of wrought iron you would have a corresponding increase of surface of contact joint or no joint. If there was a welded joint between the two, it would still have to have that increased surface of contact. That is a different thing from the question of joint between two separate pieces, and that is the thing that I was particularly insisting upon. Incidentally, we do obtain a very good joint because that core is made exactly true and exactly to a certain guage. And so is the hole into which it fits and that slips into there absolutely with no lost motion at all. That means that the feed is right within a fraction of a thousandth of an inch, and I think such a thing is desirable, particularly where your magnetic circuit is of low reluctance. I have made a test in which you could slip a visiting card into a joint due to the fact that one side was kept out by a little piece of dirt, and yet when you made the joint perfect it made no perceptible difference, because the rest of the magnetic circuit has such a large resistance that that was of no consequence. But if the rest of the circuit had a small resistance it is of great consequence. In regard to the pole piece device being brought nearer on the upper side, I would say that the object of that is to equalize the tendency of a greater number of lines of force to go through the narrow side. I find that is so and that we get 50 per cent of the lines of force through the middle of the pole piece.

The object of the plow form of the pole piece is to make the teeth come into the field gradually. That pointing action does it, and the increased distance also has the effect of making gradual the entrance or exit of coil or tooth, and I think that quite important, particularly in toothed armatures. What Mr. Mailloux said agrees exactly with my experience, that toothed armatures should have a flaring pole piece, and should have a rounded pole piece also. It is also desirable both on account of the effect of sparking and keeping the lines of force in the middle of the armature, rather than have them pile up in one corner. Another thing is that if you have a perfectly square edge and a perfectly square tooth, it will produce a hum due to the sudden effect produced, when the edge of the tooth comes opposite the edge of the pole piece, but if the edge of the pole piece has no definite position and the passage is gradual, then the hum is reduced. In regard to two sections in one slot I would say that we do not equalize it, and I expected a tendency to spark in one of them more than in the other. That is to say, I expected to have the sparking of the armature indicate that there were two sections on one slot, but it doesn't seem to occur. You cannot say that the joint between the two sections is any different from the joint in the next two sections. Of course, if two sections are in a slot that means that between one pair of sections there is one tooth, between the next pair there is a tooth and that apparently ought to have an effect, but it doesn't. I attribute it to what Mr. Mailloux spoke of—the continuity of the magnetic surface. We have practically a continuous magnetic circuit, and therefore when a tooth comes in or out of the field it doesn't suddenly come in or go out. But I was quite surprised when we were able to bring two sections into a slot without having a sparking result either, while I expected it between the sections where it went from the top section of one slot to the under section of the next slot. I expected more sparking between the two sections in the slot.

Mr. Mailloux: In regard to the air resistance, I think the matter can be put very clearly in this way: Between two wrought iron surfaces, or between two cast iron surfaces I think you can deal with the resistance as if it were an air resistance, but if you are dealing with a wrought iron and cast iron contact, in which the wrought iron happens to be the smaller of the two, I do not think that you can deal with it as if it were an air resistance. Let us assume, for instance, that we have a rod of iron making a butt joint, and that the rod has a square centimeter of section; now, if the section of the iron is only one square centimeter, also making a butt, and with a density, say, of 20,000, it will bring down the permeability of the wrought iron to, say, 20 or 40; whereas, in the cast iron the permeability will be almost literally nothing, two or three perhaps, possibly even less. So that not only have we to take into consideration air resistance, but we have to consider the immensely increased magnetic reluctance due to the greater density to the square inch in the cast iron itself, because the cast iron will not admit of such density as the wrought iron.

Fig. 7.



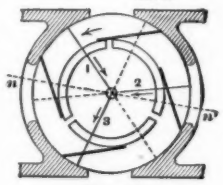


Fig. 10.

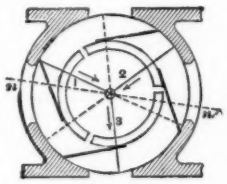


Fig. 11.

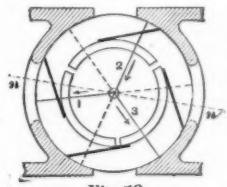


Fig. 12.

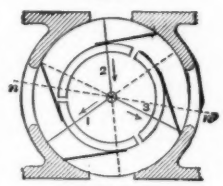


Fig. 13.

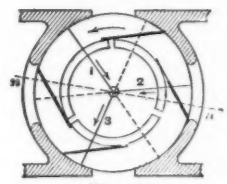


Fig. 14.

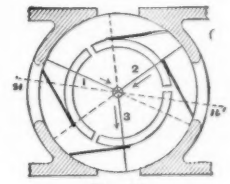


Fig. 15.

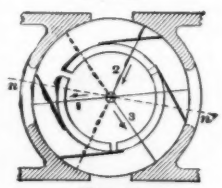


Fig. 16.

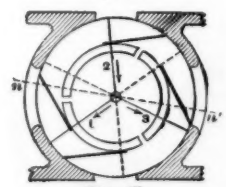


Fig. 17.

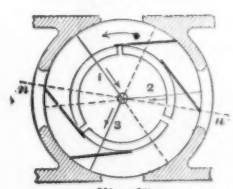


Fig. 18.

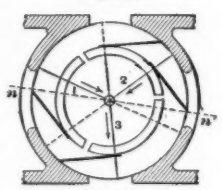


Fig. 19.

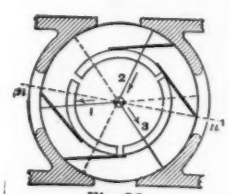


Fig. 20.

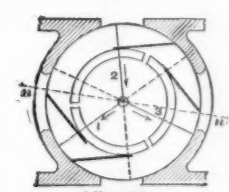


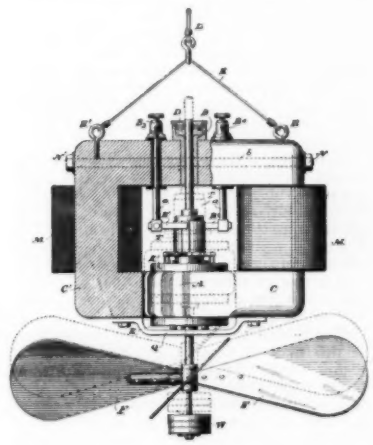
Fig. 21.

A Study of an Open Coil Arc Dynamo.—See Page 202.

The chairman (Mr. Thos. D. Lockwood): The discussion seems to have concentrated mainly on the importance of having a perfect magnetic circuit. I do not know that that was the design; in fact, I am quite sure it was not the design of the author, as much as to emphasize the necessity of the perfection of joints between cast and wrought iron. I have been specially interested in one remark which did not seem to attract general attention, namely, the supposition that cast iron is cheaper than wrought iron, which is a fallacy, as its permeability is as much above wrought iron as is its price, both being about one-half. While I am in entire accord with the spirit of that paragraph, I would venture to so far depart from its terms as to say that cast iron is cheaper than wrought iron and therefore it is not advantageous to use it. (Applause.) Some years ago, at the suggestion of our past president, Mr. Franklin L. Pope, I wrote an article entitled, "The Cheap John in Electricity." Perhaps it has had as wide a circulation as anything I have had the misfortune to write, but it is the one thing that I have written of which I am the least ashamed. I do not think that cheapness should be obliterated from electrical considerations. Substitute for the word cheap, economy, and it is all right, but there is no economy in using cast iron instead of wrought iron, even though its price be one-half.

Pneumatic Regulation for Motors.

A novel system of motor regulation has been designed by Mr. Chas. J. Kintner, of New York, depending for its operation upon the thrust imparted to a shaft by a fan. The motor is illustrated in partial section in the accompanying engraving. The armature shaft is mounted vertically, one end being seated at the neutral point of the field magnet, and the other supported in a non-magnetic bridge across the pole-pieces. The protruding end of the shaft carries a fan which is forced upwardly by the air resistance when the shaft takes a high speed, and thus lifts the armature up and out of the field of force between the pole-pieces C. C. Under ordinary conditions of operation, when the motor is working under a light



load the fan raises the armature, the tongue is weakened by reason of fewer lines of force being intercepted by the armature, and the motor becomes self-regulating. The motor is chiefly designed for fan work, and when so used the speed is sufficient to hold the armature practically suspended like Mahommet's coffin, in mid-air, thus decreasing the frictional resistance at the shaft seats, and reducing cost in wear and lubricating material. A weight W may be used to adjust the motor to different speeds as it will be evident that within certain limits the speed will be higher with increase of weight, since, under its influence, the armature will be held more nearly central with relation to the field of force.

Mr. J. D. Bishop, a gentleman of ability and experience in electrical matters, has recently joined the New York city staff of the Messrs. Roebling's Sons, the large electric wire manufacturers.

An interesting piece of apparatus exhibited during the visit of the British Physical Society to Cambridge was Prof. Thomson's 50 feet vacuum tube glowing from end to end with a luminous discharge.

The Perfection of Stationary Electric Motors.

READ AT THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, NEW YORK, MAY 20, 1891, BY FRANCIS B. CROCKER.

INTRODUCTION.

A study of the history of the electric motor shows us that from the very beginning to the present time there has been a great tendency toward complicated, fanciful and unpractical designs, including outlandish forms of field magnets and unnecessary multiplicity of field cores and coils. In most cases also the mechanical construction has been very bad, the shaft being too small, the bearings being weakly supported, and the general finish and workmanship being rough and not up to the standard of first-class machinery. From the electrical standpoint the insulation has been very poor and shares equally with imperfect mechanical construction, the responsibility for the numerous troubles and failures which have occurred with electric motors. The magnetic circuit of motors has also been designed in a way that indicates entire ignorance of the laws governing the production of a strong magnetic field. In all these respects the electric motor has been worse than the contemporaneous dynamo electric machine, the reason being, I think, that the men who have studied and designed the dynamo have been more competent than those who have turned their attention to the electric motor, electric power being comparatively a more recent development of electricity than electric lighting. There have been, of course, notable exceptions to the general badness of motor design and construction, but in the case of all of these exceptions, which are few, I think it will be found that the superiority of the motor in each particular case was directly due to the presence of an electrical engineer of recognized ability.

Electric motors are used for three different classes of work. First, transmission of power over considerable distances, for example, from Niagara Falls to Buffalo; second, distribution of power, for example, in a district of a city, from a central station, and third, electric railway work.

The first of these classes of work usually requires large motors, over 50 or 100 horse-power; the second requires comparatively small motors, ranging between one-eighth and ten horse-power; the third requires motors from 20 to 100 horse-power and a peculiar construction adapted to their special purpose. I purpose to consider in this paper motors of the second class, for distribution of power especially.

It has long been my opinion that the proper way to design a good electric motor is to consider very carefully and systematically each part, first by itself, and then with reference to the other parts, and thus collect and build up the elements which are best, not only in themselves but also in combination with each other, so that, finally, by putting and fitting these parts together with the best possible workmanship, the best result will certainly be obtained. The correctness of this procedure is so self-evident that it seems hardly necessary to uphold it, but every one familiar with electric designing of all kinds will admit that the usual process has been to invent some peculiar form of armature or field and then attempt to fit the rest of the machine to this particular part, producing all sorts of anomalous and awkward constructions. It will also be admitted that experience has taught us that the simpler and less extraordinary forms of machine have usually been more successful. In fact, I believe there is no kind of electrical apparatus in which sensationalism in design has been successful, except, perhaps, in arc light dynamos. Let us now take up the various parts of the electric motor, and consider each as a simple problem in designing.

BASE.

This should be a solid iron casting, flat and simple in form, and resting directly and squarely upon the base frame or floor, which latter should preferably be of wood to secure insulation. The base should be heavy to bring the center of gravity low; in fact, this is the only part of the machine where weight is not only not objectionable, but very beneficial, and since it is merely of plain cast-iron the extra cost is insignificant. A heavy base does more than anything else to give great stability and strength to the whole machine, and is highly desirable in a stationary motor. The bearings should be directly and rigidly mounted upon this base a simple fact that is often disregarded.

FIELD MAGNETS.

The field magnet should be *bi-polar*, except in the larger machines, above ten horse-power, on account of the great complication caused by the increased number of armature sections, commutator bars, field coils, etc., necessary in multipolar machines, and the narrowness of the neutral or non-sparking space on their commutators; for example, multiple brushes or cross-connected armatures are particularly objectionable in small machines. The field should also be a single magnetic circuit rather than the consequent pole type, because the former is more economical in wire and current required. For example, one turn of wire around a seven inch core is equivalent to the two turns of wire around two five inch cores, the cross-section of one seven inch core being nearly equal to that of two five inch cores, whereas, the length of wire is only 70 per cent. as much with the single core. In other words, a single circuit requires only 70 per cent. of the weight of wire and 70 per cent. of the energy of magnetization that is required by a double magnetic circuit. A triple magnetic circuit or quadruple magnetic circuit—that is, three or four cores magnetically in multiple arc, are still more

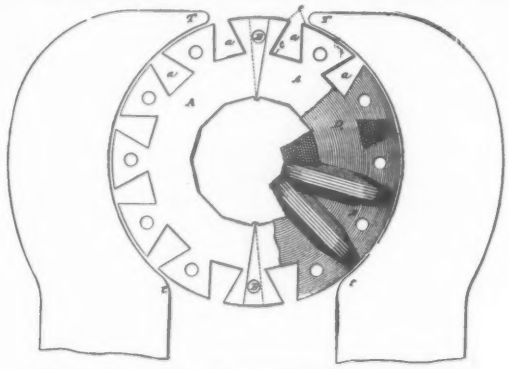


FIG. 1.—ARMATURE OF CROCKER-WHEELER MOTOR.

objectionable, requiring about twice as much wire as a single core of the same total cross-section.

The field magnet may be arranged with respect to the base described above in three general ways: First, the pole-pieces may be set upon the base (Edison type); this form requires non-magnetic material, usually a zinc plate, to be interposed to prevent magnetic short circuiting through the iron of the base; even with a zinc plate, Hopkinson found 10.3 per cent. magnetic leakage through the base of the Edison-Hopkinson dynamo.

Second, the iron base may form one of the pole pieces (Manchester type). This is also objectionable on account of the greatly increased magnetic leakage, which is practically proportional to the surface exposed to the air, and the extension of the base necessary for the bearings, etc., greatly increases this surface, and also allows the magnetism to leak up into the shaft, pulley, etc., causing various troubles. This form has the further objection that it is of the consequent pole type, the disadvantage of which I have just pointed out.

Third, the iron base may form the yoke of the field magnet with the cores and pole pieces extending upward (Kapp or "inverted horseshoe" type). This plan has neither the leakage nor other faults of the other forms and possesses the great advantage that the pole pieces are removed as far as possible from the base, bearings, etc., thereby avoiding magnetic leakage; and the base being purposely made heavy for stability and strength, as already stated, is, therefore, exactly suited to being used as the yoke, thus performing two functions to the best advantage. There is, moreover, no objection to using a cast-iron base as the yoke to complete the magnetic circuit, since the heavy base I have insisted upon is of large cross-section and, therefore, of ample magnetic permeance, and the increased size of the iron yoke does not aggravate the magnetic leakage because it is magnetically neutral. The field cores should be of wrought-iron because the field wire surrounds them, and the use of cast-iron, which is of low permeability, would require a core of almost twice the cross-section, and, therefore, a much greater length of wire to obtain the necessary magnetizing force. With the smaller wrought cores the magnetic leakage would also be less. The pole pieces should also be wrought-iron to reduce their size and, therefore, their magnetic leakage, they being at the highest magnetic potential of any part of the machine. In regard to magnetic leakage, I would call attention to the fact that it is objectionable not only on account of wasting lines of force, but because it affects electrical instruments, watches, etc., in a very troublesome manner.

The field magnet cores and pole pieces being preferably of wrought-iron, the question of uniting them to the base and to each other next arises. Since any considerable fitting or working of wrought-iron is difficult and costly, the best solution of this problem certainly seems to be to forge (*i. e.*, drop-forge) the core and pole piece in one piece. This also permits the bore or space for the armature to be perfectly formed at the same time. In connecting these cores to the cast-iron base, it is practically essential to set them into it in order to get sufficient contact and strength; since the ordinary butt joint between wrought and cast-iron limits the magnetic conductivity almost as much as if cast-iron were used throughout. This method of putting the magnetic circuit together reduces the work of fitting wrought-iron to a minimum, which work is the only objection to the use of wrought-iron. The supposition that cast-iron is cheaper than wrought for magnets is a fallacy, as its permeability is as much below that of wrought-iron as is its price, both being about one-half.

FIELD COILS.

These should, of course, be perfectly insulated, a result which can be accomplished with certainty by winding them on a solid spool of material which is fire and water proof and highly insulating. These spools should never be made of material that softens by accidental heating of the wire, as this would allow the wire to cut through and make a "ground" on the core which is just what the spool should prevent. I have tested spools of this kind which cut like cheese when a wire heated by a current was applied to them, this being a very effective method of testing this point.

ARMATURE.

In regard to the choice between the ring and drum forms of armature, the advantage of the drum is that it is easy to support mechanically, but it is difficult to wind, as the wire is apt to slip out of place and leap out on the ends of the drum, and more serious than anything else is the fact that the wires of a great difference of potential cross or approach very near each other, causing great liability to short circuit. The ring armature is somewhat hard to support mechanically, but the winding does not tend to slip out of place or pile out on the ends, and wires of the greatest difference of potential come at the greatest distance apart, that is, on opposite sides of the armature. This is of the utmost importance in the case of high voltage machines. In the case of large ring armatures or those with few turns of wire there is little trouble in winding; but in the case of the small ring armatures or where a great number of turns of wire are used, the ring should be split in halves to facilitate winding and put together afterward when wound.

TOOTHED ARMATURE.

The armature should have teeth or projections upon it in order to secure the following advantages:

First, to reduce the reluctance of the magnetic circuit and the weight of wire and energy of current required to magnetize it.

Second, to hold the wires in place and prevent them slipping tangentially on the core, the tendency to which is much greater than is usually supposed, there being a tangential pull of about 160 lbs. on the wires of a 10 horse-power armature, eight inch diameter, running at 1,000 revolutions per minute.

Third, the teeth protect the wires from mechanical injury, since any blow or pressure which the armature receives comes upon them instead of upon the armature wire, which is very easily injured, and the machine thereby ruined.

TRAPEZOIDAL TOOTH ARMATURE.

A certain form of teeth I have found to possess decided advantages over the ordinary parallel sided teeth and slots heretofore used. This form of teeth is considerably wider at the top than at the bottom, which, of course, makes between the teeth a slot which is wider at the bottom than at the top. This shape of tooth and slot has the following additional advantages over those of the ordinary toothed armature—first, the wire is more completely held in place, being held against centrifugal force as well as against tangential force; second, the wire is also more perfectly protected mechanically since it is almost entirely surrounded by iron; and third, the armature presents an almost unbroken magnetic surface to the pole pieces, thereby reducing to a minimum the reluctance of the air-spaces in the magnetic circuit and the magnetic leakage, and avoiding Foucault currents and loss of energy in the pole pieces. This trapezoidal form of slots and teeth can be still further taken advantage of by giving the former a shape which exactly agrees with the form of a section of winding on the inside of the ring, as shown in Fig. 1, the interior spaces for winding being divided into the necessary number of sections by radial lines. This exact conformity between the inside and outside of the winding makes a perfectly symmetrical coil, with no tendency for a single turn of the wires to cross at any point, and the coils on the inside occupy the whole space with the greatest possible advantage, whereas, ordinarily the interior of the ring is liable to be overcrowded with wires. The trapezoidal form of slot is particularly economical as regards winding, for the reason that there are a greater number of turns in the inner layers, which are shorter, and fewer turns in the outer layers, which are longer, as shown in Fig. 1. The armature teeth make it easy to support the ring perfectly, since the bolts for carrying it may pass through the teeth without interfering with the winding. These bolts being held at the two ends by brass spiders or supports, make a very strong and convenient means of mounting the ring upon the shaft, and thereby overcome the objection to the

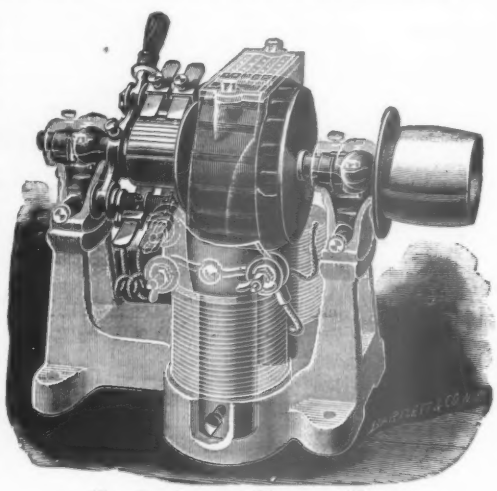


FIG. 3.—CROCKER-WHEELER MOTOR.

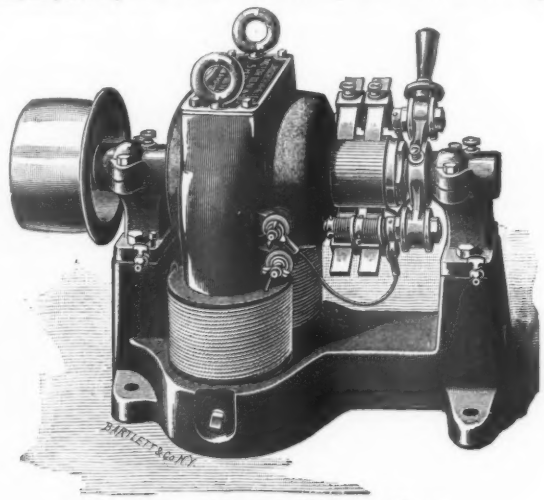


FIG. 2.—CROCKER-WHEELER MOTOR.

ring armature. In the trapezoidal form of teeth which I have described there is even more space than in the ordinary form of teeth for the bolt-holes, and in this way larger bolts and stronger support can be obtained. The perfect insulation of the armature core is of the utmost importance. The best material and the most complete covering should be used, and the greatest possible care should be exercised to avoid short-circuits, "grounds" or broken wires.

EFFICIENCY.

This should, of course, be as high as possible, and is made a maximum by reducing all elements of loss as far as possible. These losses are: Current to magnetize field, loss due to armature resistance, friction, resistance of air, Foucault currents and hysteresis. It has always seemed to me that the efficiency is necessarily high if the machine is properly constructed, and if the efficiency is low it must be due to some loss, which is more objectionable in itself than because it involves a reduction in efficiency, because this loss must necessarily manifest itself in the form of heat in some part of the machine, for example, the field-coils, armature or bearings. This heat is liable to do more harm by its direct effect upon the heated parts, causing a burn-out or charring of insulation in the winding or cutting of the bearings, and any effect of this kind is much more serious than the inefficiency from which it results. The same fact can be expressed in another way, by stating that if a machine can be run for one or two hours at full load without any part becoming overheated, the efficiency of that machine must be high, unless the machine is very large and heavy for its power, in which case the surface for radiation and conduction would be great. This fact is more absolute than any efficiency test can possibly be, and very small losses which an efficiency test might not disclose would be indicated by local heating, if, for example, the effects are allowed to accumulate for a half-hour of steady running.

THE MOTOR AS A WHOLE.

I can best illustrate the foregoing statements and recommendations by describing the set of electric motors designed by Dr. S. S. Wheeler and myself. They were developed by precisely the same process of reasoning as that given in this paper. Fig. 2 shows the general view of the motor; each of the parts and the putting together of the whole follows exactly the statements I have already made, and it is, therefore, only necessary to call attention to a few points.

The fields are put together according to a method, illustrated in Fig. 4*c*, which consists in drop forging the core and pole piece in one piece and exactly to shape; then mounting it upon a holder in such a way that the ends of the cores are trimmed with exact reference to the armature bore, and holes being bored in the cast-iron base the proper distance apart, the cores are set into it to the depth they are trimmed off, and produce a space for the armature exactly suited to it. This is much simpler than fitting the field magnets and base together and then boring out the armature space, the operation of boring being a slow one and requiring heavy machinery. The field cores set into the base are shown in the skeleton drawing, Fig. 4.

The magnetic circuit produced by this method is excellent. In the first place, there are only two joints and these are of very large surface and fit very perfectly, being where the cores fit into the base. The surface of contact of each of these joints is about four times the cross-section of the core and, therefore, about twice the cross-section of the equivalent cast-iron. The core and pole piece being made integral, avoids any joint between them, as well as any necessity for expensive work in fitting them together. In fact, the only machine work required in fitting the fields to the base is simply trimming off superficially the ends of the cores and reaming the two holes in the cast-iron base, these holes being cored out in the casting.

The armature is made with trapezoidal teeth, as shown in Fig. 1, and having an almost unbroken surface of large extent exposed to the pole piece, with a clearance of only one sixteenth of an inch, the magnetic reluctance of the air gap is reduced to the lowest possible value. This exceedingly low reluctance of the magnetic circuit reduces the amount of wire required to excite the field to such an extent that only very short field coils and cores are needed, being only about one-third or one-quarter of the length required with armatures having no teeth and the ordinary air gaps in the magnetic circuit. This small quantity of wire on the field, amounts to only 1¼ pounds in a three horse-power machine and 16 pounds in a five horse-power machine. It has not only the advantage in economy of wire, but also makes the machine very efficient as regards current consumed in the field, being less than two per cent. in the two machines referred to. The reduction of field wire and length of coil required is particularly important in bringing the shaft of the machine down sufficiently near the floor to give the machine stability and steadiness in running. In fact, the only objection to the "inverted horseshoe" type of field is that heretofore it has involved the use of long field coils which brought the shaft almost twice as high above the base as it is desirable to have it, giving a top-heavy and unsteady result. In the type of motor described, the shaft center is less than a foot from the floor in the three horse-power size, and is just about the proper height to make the pulley, belt, gear wheels or other mechanical connections clear the floor and have sufficient room to work properly. This complete overcoming of the heretofore serious objection to the "inverted horseshoe" type makes a thoroughly satisfactory field construction without any of the disadvantages of all the other forms.

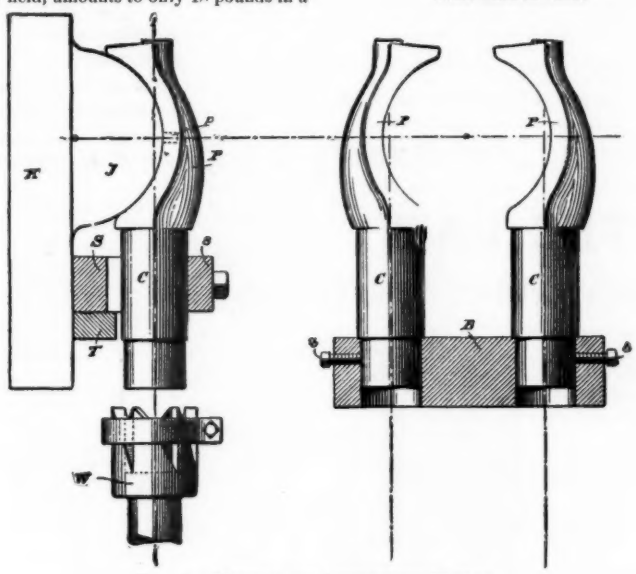


FIG. 4.—METHOD OF ASSEMBLING FIELDS.

The actual results obtained from these motors, which, of course, is the most important and conclusive thing to know, are given in the following table and include the various mechanical, electrical and magnetic constants of the machine. All the sizes of this type of motor are made almost exactly the same in design, proportions and construction, and differ only in scale, hence a description of one machine applies to all, with proper allowance for difference in size.

Data of three horse-power Crocker-Wheeler motor, designed for 115 volt constant potential circuit:

Total weight, 350 pounds; Weight of field wire (No. 24, A. W. G.) 12 pounds; Weight of armature wire (No. 13, A. W. G.) 11 pounds; Resistance of field, 310 ohms; Resistance of armature, .4 ohm; E. M. F. of circuit, 115 volts; Total current at full load, 24.3 amperes; Current used to excite field, .37 ampere; Percentage of current used in field, .015; Total current required to run free, 1.9 amperes; Percentage of total energy to run free, .8; Commercial efficiency, .80; Armature speed, 975 revolutions per minute; Total magnetic leakage or waste lines of force, .17; Magnetic efficiency =

$$\frac{\text{Lines through armature}}{\text{Total lines of force}}, .83.$$

The above data for the most part explain themselves, but I desire to call attention to several particularly interesting points.

The weight of field wire is extremely small, being only 12 lbs., compared with about 40 to 50 lbs. in most machines of this size. I actually found the weight of field wire to be 60 lbs. in a type of motor of equal capacity, which is claimed to have the best possible magnetic circuit.

The table also shows the current used in field to be only 1½ per cent., which is remarkably low for machines of this size, which usually require about five per cent.

The current required to run free, at full speed, is also exceptionally small, being only eight per cent.

The commercial efficiency is high for a motor of this size, particularly when the very low speed is considered, because an increased number of turns of wire on the armature is required to make up for the reduced speed, and this augments the armature resistance and causes loss. The efficiency does not vary more than about one per cent. from half to full load, which is quite an interesting fact.

The speed, it will be noticed, is very low for this size of machine.

The magnetic leakage or loss of lines of force is extraordinarily small, amounting to only 17 per cent. and giving what may be properly called a magnetic efficiency of 83 per cent.

This small magnetic leakage is due to the facts already stated in this paper in regard to the design of the field magnets. In this connection it should be remembered that Hopkinson in his classical investigations of the magnetic circuit found that there was 24.24 per cent. magnetic leakage in the Edison-Hopkinson machine. I may also state that Mr. A. S. Ives, student in electrical engineering at Columbia College, found 40 per cent. leakage in a well-known dynamo (400 light) of a recent though not the very latest type.

In conclusion, I would state that it is obviously impossible in one paper of reasonable length, to completely treat the subject of motor design, but I have attempted to bring out the most important points, and lay before the Institute the best results of considerable study and experimental work on the part of Dr. Wheeler and myself in the direction of improving and perfecting the design and construction of stationary electric motors.

There is one single merit in the paper to which I lay claim, and that is the fact that the ideas I have advanced are embodied in a large number of actual working machines which are open to any one for examination and criticism, whereas, the design of electric motors is usually given on paper only, and is, therefore, very intangible, and correspondingly safe, so far as the author is concerned.

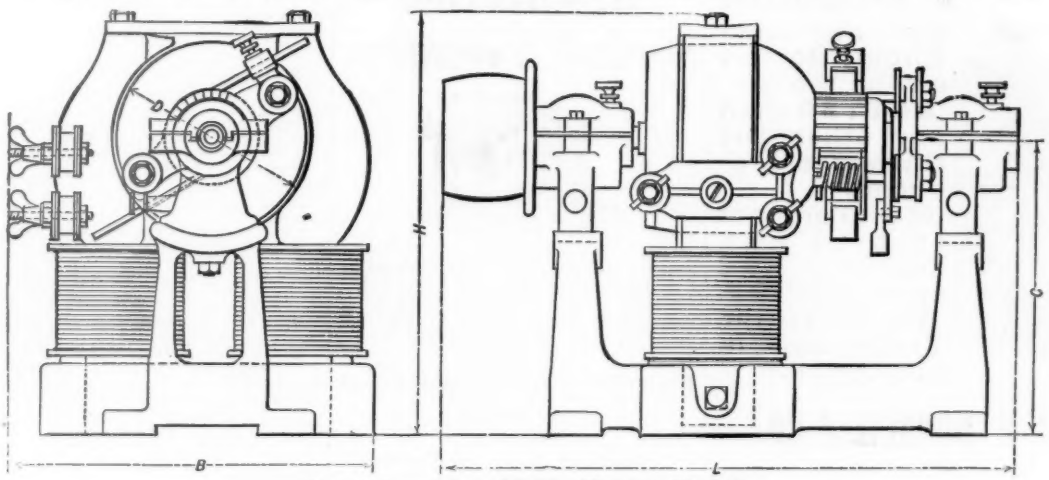


FIG. 5.—DIAGRAM OF CROCKER-WHEELER MOTORS.

Electricity Applied to Agriculture.

Experiments on a large scale have, during several years, been carried out by M. Spechnew with the view of ascertaining the effect produced on vegetable growth by the influence of electricity, says the London *Electrical Review*. The conclusions arrived at are: 1. Seeds submitted to the effects of an induced current develop more quickly and more vigorously. 2. The influence of a continuous current is shown in a quicker development, in a more abundant harvest, and in the production of vegetables of enormous size. 3. The slow discharge of static electricity assists plants in assimilating nitrogen. The following table shows the increased yield on various vegetable growths due to the application of electricity, or electro-culture, as it is termed:

Plant.	Increase per cent.		
	Grain.		Straw in weight.
	In size.	In weight.	
Rye	29	28	60
Wheat	56	56	1
Oats	57	62	58
Barley	48	55	18
Peas	22	25	23
Clover	32	31	18
Potatoes	11	11	34
Flax	42	44	16

M. Spechnew also claims that electro-culture protects plants from the infectious diseases natural to them. In the case of beet-root, it has invariably been found impracticable to artificially communicate infection where electricity has been employed during cultivation.

ELECTRICAL NEWS FROM SUBURBAN SOURCES.

Henry Mills, of Delphi, in the employ of the electric light company, claims that the loud-smelling water flowing from the artesian well in that city possesses valuable properties in generating electricity.—*Indianapolis News.*

The Redlands *Citrograph* wants electric lights. What's the matter with your rubicund visage, Scipio? It should be sufficient to illuminate a whole State.—*Oakland, Cal., Times.*

To be—killed by an electric wire or not to be—killed by an electric wire?

That is the question uppermost in the mind of the average Atlantian since the tragic taking off of the little bay mule on Broad street.—*Atlanta, Ga., Journal.*

It should be understood that Lawyer George B. Metzger did not cut down that electric street car pole simply because he thought the company had no right to erect their poles in the street. The company had erected a pole on the corner of Mr. Metzger's lot and had started to erect a pole on the lot of Mr. Bates on the opposite side of the street. Mr. Bates objected and the pole on his side of the street was placed further to the East. The company then wanted to erect another pole on Mr. Metzger's lot, about midway between the two corners. It was then that Mr. Metzger made up his mind to stop them from literally fencing him in, and accordingly cut down the pole. Mr. Metzger says that he has no intention of questioning the right of the company to erect their poles, but he maintains his right to object to them putting two poles in front of his house to disfigure his property.—*Williamsport, Pa., Sun.*

KINDRED INTERESTS

The Mason Battery and Electrical Company, 257 Broadway, New York, have issued a catalogue of primary batteries and electrical supplies.

The Colburn Electric Manufacturing Company, Fitchburg, Mass., are issuing an advance sheet with handsome illustrations of their dynamos for lighting and plating, and motors for constant potential.

Large Wire Contract.—In connection with the large arc lamp installation to be placed in the new Fair building, Chicago, the Central Electric Company has secured the contract for furnishing the wire, and, of course, will supply their celebrated Okonite. This will be probably the largest isolated arc light plant in the country.

H. T. Paiste, the enterprising electrical specialty manufacturer, of Philadelphia, recognizing the want of a store-room and office in Chicago, has opened out at 341 The Rookery, that city, where his Western friends and patrons can be supplied without having to order from the factory in the East. The move seems a popular one among the supply men of the West, as it will save them the necessity of ordering in large quantities to save freight and express rates. Mr. Paiste still continues his Eastern office and factory at 1201 Market street, Philadelphia. The Western office will be managed by Messrs. Kohler Bros. & Grier, three enterprising young men, who will do all in their power to cater to the Western electrical trade in Mr. Paiste's line of specialties, which consists of porcelain base switches, china switches (which are decorated in all tints to match wall paper), sockets, cut-outs and gas attachments.

The Eureka Tempered Copper Company, of North East, Pa., report large orders during the last 30 days from the Edison General Electric Company, Schenectady, N. Y., from the Wenstrom Consolidated Dynamo and Motor Company, Electro-Dynamic Company, Wightman Electric Manufacturing Company, Supply Manufacturing Company, Thomson-Houston Electric Company, Sperry Electric Mining and Machine Company, Baxter Electric Motor Company, "C. & C." Electric Motor Company, La Roche Electrical Works, McDonough Manufacturing Company, Shaw Electric Crane Company, Thomson Electric Welding Company, Colburn Electric Manufacturing Company, Ford & Washburn Electric Company, together with a large number of orders for railroad bearings, and even with the dullness now pervading in business circles, the demand for their tempered copper has constantly increased instead of diminished.

The Thomson-Houston Electric Company has made the following recent sales through its Western isolated lighting department, Chicago: Smith Steam Baking Co., Kansas City, Mo., 50 light incandescent plant; Wainright Real Estate Co., St. Louis, Mo., 3,000 incandescent lights; Iowa Agricultural College, Amos, Ia., six arc light dynamo, 35 light incandescent dynamo, one horse-power motor, and appurtenances for laboratory use; Cudahy Packing Co., Sheffield and North avenues, Chicago, 125 incandescent lights; Carson, Pirie Scott & Co., Adams and Franklin streets, Chicago, 35 arc light and 400 light incandescent plants; S. S. Badger, Ouray, Col., 100 incandescent light plant; Central Market Co., State and So. Water streets, Chicago, 18 arc light plant and 200 light incandescent plant; Chicago City Railway Co., 150 light incandescent plant, and H. H. Shufeldt & Co., 23 Larabee street, Chicago, 250 light incandescent dynamo to increase capacity of plant sold last November.

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Planers, 16 in. x 16 in. x 3 ft.; 20 in. x 20 in. x 4 ft.; 24 in. x 24 in. x 6 ft.; 30 in. x 30 in. x 6 ft.; 36 in. x 36 in. x 10 ft.; 42 in. x 42 in. x 12 ft.; 72 in. x 60 in. x 15 ft.; 72 in. x 60 in. x 20 ft.

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ELECTRICAL PATENTS

INDEX OF INVENTIONS FOR WHICH LETTERS PATENTS OF THE UNITED STATES WERE ISSUED ON MAY 26, 1891.

452,725 Insulated electric conductor; James B., Williams, Oakland, Cal.

452,735 Electric alarm; Charles H. Shaffer Rockford, Ill., assignor to the Electric Alarm Co., Muskegon, Mich.

452,741 Electric Railway System; David G. Weems, Baltimore, Md., assignor to the Weems Electric Railway System, of West Virginia.

452,758 Microphone; August C. F. Müller, Berlin, Germany, assignor to Mix & Genest, same place.

452,775 Telephone receiver; Charles T. Dickson, Cincinnati, O.

452,780 Incandescent electric lamp; Isaac J. Flagg, Clinton, Mass.

452,785 Coin-controlled annunciating machine; Harry M. Hamrick, Philadelphia, Pa.

452,795 Electric motor; Charles J. Kintner, New York, N. Y.

452,799 Hanger for incandescent lamps; James A. Matteson, River Point, R. I.

452,871 Automatic safety electric system for locomotives. 452,872 Automatic safety electric system for railways. 452,873 Automatic electric safety system for railways, switches and draw-bridges. 452,874 Automatic electric safety system for railway crossings; Edward Deming, Brooklyn, assignor of two-thirds to Adolph Kaufmann and Isaac Stern, New York, N. Y.

452,875 Multiple fuse-block; Lorenzo B. Favor, Gloucester, Mass., assignor to the Thermal Electric Company, same place.

452,913 Sextuplex telegraph; Thomas A. Edison, Menlo Park, N. J., assignor to the Western Union Telegraph Company, New York, N. Y.

452,920 Electric railway; Rudolph M. Hunter, Philadelphia, Pa., assignor to the Electric Car Company of America, same place.

452,921 Electrical switchboard; John B. Lyon, Brooklyn, N. Y.

452,931 452,932 Electro-mechanical gong; Frederick W. Cole, Newton, Mass., assignor of one-half to Moses G. Crane, same place.

452,934 452,935 Electric motor or generator. 452,936 Electric meter. 452,937 Electric switch; Walter K. Freeman, Brooklyn, N. Y., assignor to William S. Hadaway, Jr., trustee Boston, Mass.

452,941 Dynamometer; Charles E. Scribner, Chicago, Ill., assignor to the Western Electric Company, same place.

452,942 Air-brake system; William W. Slater, Oakland, Cal.

452,951 Armature for dynamo electric machines or motors; Elihu Thomson, Lynn, Mass., assignor to the Thomson-Houston Electric Company, of Connecticut.

452,955 Electric transmitting clock. 452,956 Synchronizer for electric clocks; Henry S. Prentiss, Elizabeth, N. J.

452,976 Governor for phonographs; Henry D. Goodwin, Milwaukee, Wis.

452,992 Electric motor for wheeled vehicles; Robert S. Dobbie, Jersey City, N. J.

453,000 Electric connection for distributing telephone lines; William M. Geodridge, Highland Park, assignor to the Western Electric Company, Chicago, Ill.

453,002 Adjuster for electric lamp reflectors; James E. Hamilton, Chicago, Ill.

453,029 Multiple cut-out for electric distribution systems; Ernest P. Warner, Chicago, Ill., assignor to the Western Electric Company, same place.

453,031 Electric motor; Elbridge Baker, Malden, Mass.

453,032 Automatic electric switch mechanism; Harry H. Blades, Detroit, Mich.

453,036 Adjustable support for electric wires; Thos. H. Brady, New Britain, Conn.

453,041 Electric display burner for oil lamps; William A. Drysdale, Philadelphia, Pa.

453,043 Rotary motor; Ernest Filtz, Joseph Filtz and George Filtz, Paris, France.

453,046 Electrical safety switch; George L. Hall, Lowell, Mass.

453,070 Support for trolley wires; George K. Wheeler, Chicago, Ill.

453,093 Trolley wheel; John Sullivan, Washington, D. C.

453,095 Tramway; John F. Vinton, Spokane Falls, Wash., assignor of one-half to Joseph S. Ham, same place

453,097 Electric railway signal; Willie Cowles Walter, Richmond, Va., Sophia Lee Walter, executrix of said Willie Cowles Walter, deceased.

453,100 Insulating clamp for span wires; William E. Baker and Charles H. Macloskie, Boston, Mass.

453,104 Electric contact brush; James R. Branch, Richmond, Va.

453,111 Electric fuse-box; William Edson, Boston, Mass., assignor to the Beacon Vacuum Pump and Electrical Company, of Maine.

453,162 Apparatus for hardening and tempering steel and iron. 453,163 Method of, and apparatus for, hardening and tempering steel and iron. 453,164 Art of repairing metal structures by the aid of electricity; Elias E. Ries, Baltimore, Md.

453,167 Electric locomotive or street car motor; Rudolf Eickemeyer, Yonkers, N. Y., assignor to the Eickemeyer-Field Company, New York, N. Y.

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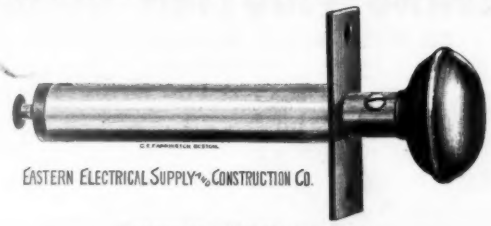

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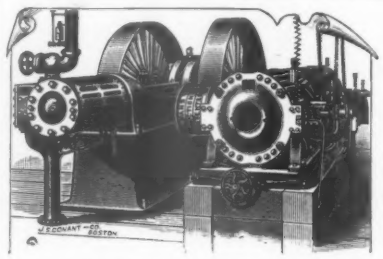

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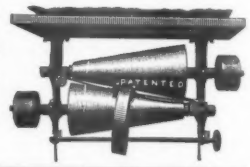

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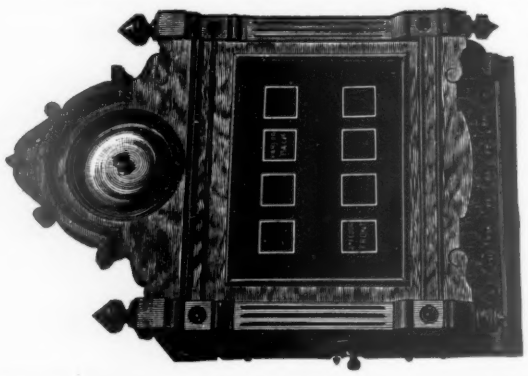

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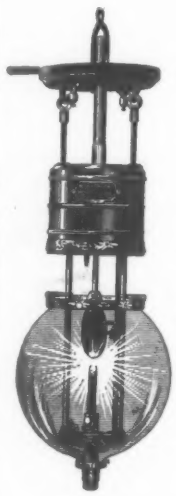

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